federal register

FRIDAY, MARCH 24, 1978
PART III

ENVIRONMENTAL PROTECTION AGENCY

■

CONTROL OF AIR POLLUTION FROM AIRCRAFT AND AIRCRAFT ENGINES

[6560-01]

Title 40—Protection of the Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

[FRL 845-3; Docket No. OMSAPC-78-1]

PART 87—CONTROL OF AIR POLLUTION FROM AIRCRAFT AND AIRCRAFT ENGINES

Amendment to Standards

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: Published elsewhere in this issue, the EPA is proposing a wide range of changes to gaseous emissions standards applicable to aircraft and aircraft engines which were promulgated on July 17, 1973 (38 FR 19090). This final rule sets back by 2 years, until January 1, 1981, the effective date for all gaseous emissions standards which would otherwise have been effective on January 1, 1979 for newly manufactured aircraft and aircraft gas turbine engines. This change in compliance date will allow more time for analysis of comments received during the public comment period and public hearings on the proposed changes to the standards, before their final promulgation. It will additionally permit a thorough reassessment of the air quality impact of aircraft operations at large metropolitan airports.

EFFECTIVE DATE: April 24, 1978.

FOR FURTHER INFORMATION CONTACT:

George Kittredge, Senior Technical Advisor, Office of Mobile Source Air Pollution Control, Environmental Protection Agency, Waterside Mall, Washington, D.C. 20460, 202-426-2464.

SUPPLEMENTARY INFORMATION: The EPA and FAA have agreed that a reanalysis needs to be made of the air quality of aircraft emissions impact, so as to place final action with respect to amended standards on the soundest possible basis. The principal issue in this reanalysis is the degree of need for control of NOx emissions from aircraft (see also below). It is estimated that such an analysis, to be reasonably comprehensive, cannot be completed until mid-1979. To take full advantage of this reanalysis, final rulemaking related to the NOx standard based on this new information will not be possible until 1980.

Another development which bears on the timing for promulgation of the subject amendments is the requirement in the 1977 Amendments to the Clean Air Act that the EPA take action on a short term ambient air quality standard for NO2 by August 1978. It is expected that such action by the EPA might significantly strengthen the need for NOx standards applicable to aircraft and aircraft engines. It appears prudent for EPA to delay final action on amended NOx standards applicable to aircraft until a fully developed position has been taken with respect to a short term ambient air NO2 standard. This in itself would delay final rulemaking on an NOx standard until relatively late in 1978.

In addition, the proposed changes to the currently promulgated aircraft and aircraft engine standards, which are being published concurrently with this action, extend over a wide range of technological issues. The comments expected to be submitted to EPA on the proposals are likely to be detailed and extensive. Further, the EPA will be conducting, during the comment period, an analysis of the economic impact of the proposed changes which is to be published separately at least 30 days prior to the end of the comment period, which has been extended to 120 days to allow for this action. Therefore, it is likely that thorough technical analysis of all the technical and cost information received will extend well into the fall of 1978, which would cause the final promulgation of the amendments to the standards to fall undesirably close to the January 1, 1979 implementation date for the current standards applicable to newly manufactured gas turbine engines.

ACTION

With due consideration of the foregoing, it has been determined that the effective date for all gaseous emissions standards scheduled to be implemented on January 1, 1979, should, as an interim measure, be postponed by 2 years to January 1, 1981, so as to permit the continued manufacture of aircraft gas turbine engines during the period between January 1, 1979, and the compliance date specified in the final amended standards. This action will allow reasonable time for completion of all activities discussed above and will facilitate the establishment of final revised standards based on the best obtainable information in the areas of emissions control technology, costs of applying such technology, and air quality impact of commercial aircraft operations. The Agency finds, for the reasons outlined above, that notice and public procedure thereon are impractical, unnecessary, and contrary to the public interest.

This rulemaking action does not constitute a regulation which will result in major economic impact. Accordingly, the Environmental Protection Agency has determined that this document does not contain a major proposal or a substantial revision requiring preparation of an economic impact analysis under Executive Orders 11821 and 11949, OMB Circular A-107, or section 317 of the Clean Air Act.

Dated: March 10, 1978.

DOUGLAS M. COSTLE,
Administrator.

Part 87, Chapter I, Title 40 of the Code of Federal Regulations, is amended as follows:

1. Section 87.21(d) is revised to read as follows:

§ 87.21 Standards for exhaust emissions.

* * * * *

(d) Exhaust emissions from each aircraft gas turbine engine of the classes specified below manufactured on or after January 1, 1981, shall not exceed:

2. Section 87.51(a) is revised to read as follows:

§ 87.51 Standards for exhaust emissions (new aircraft).

(a) Exhaust emissions resulting from the generation of onboard power from each new aircraft manufactured on or after January 1, 1981, shall not exceed:

* * * * *

3. Section 87.52 is revised to read as follows:

§ 87.52 Standards for exhaust emissions (in use aircraft).

Exhaust emissions from each in-use aircraft manufactured after January 1, 1981, resulting from generation of onboard power shall not exceed the level of the emission standards applicable to such aircraft when it was new.

(Secs. 231, 301 of the Clean Air Act, as amended (42 U.S.C. 7571, 7601, formerly 42 U.S.C. 1857f-9, 1857g).)

[FR Doc. 78-7599 Filed 3-23-78; 8:45 am]

[6560-01]

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 87]

[FRL 845-4; Docket No. OMSAPC—78-1]

CONTROL OF AIR POLLUTION FROM AIRCRAFT AND AIRCRAFT ENGINES

Proposed Amendments to Standards

AGENCY: Environmental Protection Agency.

ACTION: Proposed rule.

SUMMARY: In 1973 EPA promulgated gaseous emission regulations for several classes of newly manufactured and newly certified aircraft engines (40 CFR Part 87). EPA also proposed standards for large in-use gas turbine engines; this standard has not yet been promulgated. This notice proposes changes to the existing rules and supersedes the earlier proposal. The most significant proposed changes to the existing standards are: The addition of the classification category "commercial aircraft engines"; the revocation of emission standards for general aviation engines; modifications to the levels of the emission standards; and extensions to the effective dates for the standards. This proposal differs from the earlier proposal (38 FR 19050 July 17, 1973) requiring the retrofit of in-use engines in that it extends the applicability to all commercial aircraft engines of 12,000 pounds thrust or greater in place of the previously proposed applicability of 29,000 pounds thrust or greater, deletes the requirement for retrofit of oxides of nitrogen (NOx) control technology (although this requirement may be reinstituted in the future), and extends the proposed effective date for the standards. In addition of the classification category "commercial aircraft engines" facilitates an emission control strategy which requires control of only those aircraft engines which have been determined to be the major cause of air pollution at high activity major air terminals. The proposed changes to the gaseous emission standards will require only engines of 6,000 pounds thrust (or equivalent power) or greater, used in commercial applications, to comply with gaseous emission standards. This action will withdraw emission control requirements from piston engines, small turboprop and small (6,000 pounds thrust) turbojet and turbofan engines, and auxiliary power units (APUs). These engines, with the exception of the APUs, are used on aircraft that operate mainly from general aviation airports. General aviation aircraft contribute significantly to air pollution at those airports, but the total contribution of general aviation airports, but the total contribution of general aviation airports to pollution of the surrounding region is small. The cost per ton of emissions abated from general aviation aircraft is substantially higher than the cost per ton from commercial aircraft or from other classes or sources of air pollution currently subject to control. These factors, coupled with the limited resources available to the Environmental Protection Agency for the achievement of national compliance with ambient air quality standards, cause an expenditure of EPA resources directed toward endeavoring to impose emission controls on general aviation aircraft, not to have high enough priority to merit their further pursuit at this time.

DATE: All relevant material received on or before July 24, 1978, will be considered. An economic impact assessment will be made available during the comment period. If necesary, the comment period will be extended to allow the public at least 60 days for comment on the economic assessment. Final regulations, modified as the Administrator deems appropriate after consideration of comments, will be promulgated as soon as practicable after such consideration.

ADDRESS: Interested persons may participate in this rulemaking by submitting written comments to the Administrator, Environmental Protection Agency, Attention: Office of Mobile Source Air Pollution Control (AW-455), 401 M Street SW., Washington, D.C. 20460. Ten copies are requested but not required.

FOR FURTHER INFORMATION CONTACT:

George Kittredge, Senior Technical Advisor, Office of Mobile Source Air Pollution Control, Environmental Protection Agency, Waterside Mall, Washington, D.C. 20460, 202-426-2464.

SUPPLEMENTARY INFORMATION: The APU standards are being withdrawn for several reasons. These are: (1) No NOx control technology has been developed in spite of extensive good faith efforts; (2) only minimal CO control is obtainable, yet significant costs would be incurred by both industry and the government; and (3) the HC emissions are already below the standard in the uncontrolled engine.

The newly manufactured engine standards for hydrocarbon (HC) and carbon monoxide (CO) remain at the current levels for engines of 20,000 pounds thrust and above. For commercial aircraft engines with rated thrust between 6,000 pounds and 20,000 pounds, a continuous transition of the standards with thrust is proposed to better account for the technology limitations of existing engines in this thrust range. This results in a slight relaxation of the standards. The implementation date of these standards is proposed to be delayed from January 1, 1979 to January 1, 1981.

It is proposed that the NOx standards be changed from an EPA Parameter (EPAP) of 3.0 to 4.0, with the implementation date delayed three years after the effective date for the HC and CO standards to January 1, 1984. It is further proposed that a rated compressor pressure ratio adjustment be applied to NOx emission measurement vaues for newly manufactured engines with pressure ratios greater than 25. This adjustment factor is proposed for the newly manufactured engine standards since existing engines have significantly different pressure ratios, and pressure ratio significantly affects NOx emission levels. An adjustment factor is therefore necessary to insure that the best available technology is used on all existing engines. A standard which could be met by the existing higher pressure ratio engines would require only minimal reductions (or none at all) from the lower pressure ratio engines.

In addition, the justification for imposition of NOx standards on newly manufactured aircraft engines will be reexamined after EPA has developed the necessary supporting information for responding to the August 1977 Clean Air Act Amendments relating to promulgation of a short term NO_2 ambient air quality standard. The EPA will take no action towards final promulgation of an NOx emissions standard for newly manufactured aircraft gas turbine engines until completing the necessary actions relating to the short term NO_2 standard and until a joint FAA/EPA air quality study is completed and considered. Completion of the joint FAA/EPA study is expected in the summer of 1979.

Existing rules for smoke and fuel venting standards will remain in effect as promulgated, except for a proposed modification in the T3 compliance schedule. The proposed modification will change the present full T3 engine fleet compliance date from January 1, 1981 to a phased program with full compliance by January 1, 1985. The revised compliance schedule is identical to the noise retrofit schedule specified in 14 CFR Part 91, Subpart E—Operating Noise Limits. The purpose of the extension is to avoid requiring the airlines to implement double retrofit programs or to retrofit aircraft that are scheduled to be phased out of service.

The present levels of the HC and CO emission standards for newly certified engines are considered feasible and require no change with respect to this proposed action. Based on technologi-

cal considerations it is proposed that the newly certified engine NOx standards be relaxed to the same level as that for newly manufactured engines, but without a pressure ratio adjustment. The effective date of the newly certified engine standards is proposed to be delayed from January 1, 1981 to January 1, 1984.

These proposed changes to the aircraft standards result from the continuing technology assessment which has been undertaken since the promulgation of the standards on July 17, 1973.

This proposed action would also extend the applicability of the proposed standards to certain in-use aircraft engines. The proposal of July 17, 1973 (38 FR 19050) applied only to T2 class engines of 29,000 pounds rated thrust or greater. The current proposal extends the applicability to include all commercial T2 engines of 12,000 pounds thrust or greater, and all commercial T4 engines. This results from a determination that the technology developed for HC and CO compliance with the newly manufactured engines is readily adaptable to in-use engines within a four year period, and the fact that engines in the 12,000 to 29,000 pound rate thrust category represent a substantial portion of the in-use fleet. It has also been determined that the NOx technology that has thus far evolved is not readily adaptable for retrofit and, therefore, no requirement for retrofit of oxides of nitrogen control technology is being proposed. EPA will monitor the further development and refinement of the emerging NOx control technology, and if in the future it appears this technology is reasonably capable of being retrofitted additional rulemaking will be considered. The applicability date is designed to correspond to the two year delay proposed for the newly manufactured engine standards. The proposed effective date for in-use engines thus is January 1, 1985.

In addition to the major proposed amendments summarized above, this action proposes that the units of measurement be converted to the International System of Units, that a clarification of the idle power setting be adopted and that a minor modification to the EPA parameter be incorporated into the regulations.

J.F.K. Aircraft Emissions

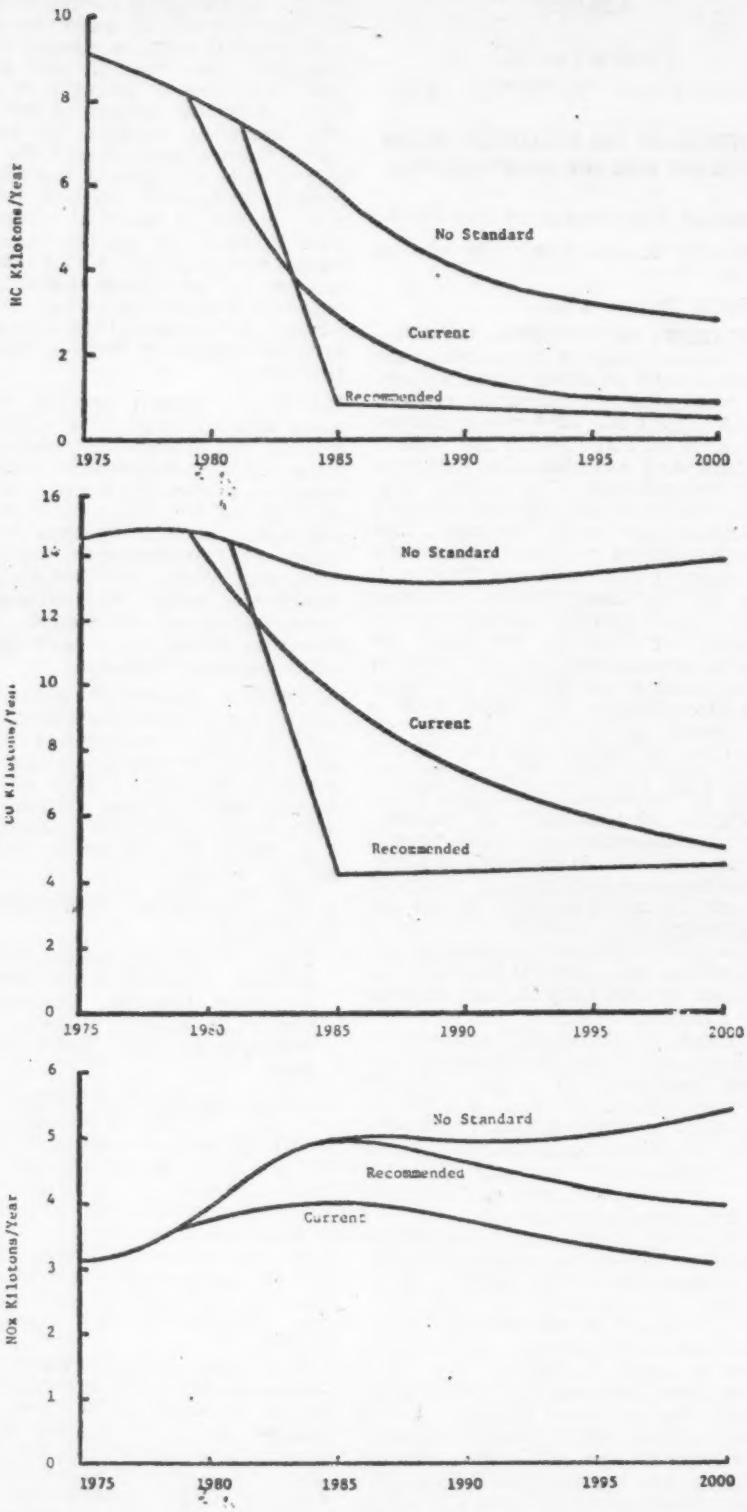


Figure 1

The proposed actions will greatly simplify the current aircraft regulations and will: (1) Eliminate expenditure of private funds and government resources, at this time, for controlling aircraft engines that contribute relatively little to air pollution problems; and (2) provide early cost-effective reduction of emissions from the existing aircraft fleet. The air quality effect of each of the changes compared to the present standards is summarized below:

Change	*Effect at major airports*
A. Elimination of standards applicable to general aviation engines and APU's.	Essentially none.
B. Change in the level of the standards.	HC: No significant effect. CO: 0 to 2 pct increase. NOx: Up to 30 to 35 pct increase (plus control delayed 5 yr).
C. Control of in-use engines in commercial aircraft only.	HC, CO: 50 pct decrease at maximum. NOx: 0 to 5 pct decrease.

While these proposed amendments in several cases represent a deletion of existing regulations and in other cases result in the relaxation of the levels of the standards and/or the implementation dates, the net result of this regulatory action will be to improve the effectiveness of the aircraft regulations for HC and CO control at the major commercial airports (aircraft air pollution problem areas), and to recognize that the full degree of NOx control called for in the existing standards is not technically achievable in the foreseeable future. The effectiveness of the existing standards as compared to the proposed standards is summarized of Figure 1. The improved effectiveness of HC and CO control is due exclusively to the proposed in-use engine retrofit standards.

Because of certain unresolved questions relating to the impact of NOx emissions from aircraft on public health, the EPA intends to participate with the Federal Aviation Administration in carrying out an updated study of the impact on urban air quality of commercial aircraft operations from large metropolitan airports, while this proposal is out for public comment. It is expected that this study will be completed by mid-1979. Accordingly, promulgation of the revised NOx standards will be delayed until completion of this study, to allow consideration of the updated air quality information.

Review of Earlier Actions

Section 231 of the Clean Air Act directs the Administrator of the Environmental Protection Agency to establish "standards applicable to emission of any air pollutant from any class or classes of aircraft or aircraft engines which in his judgment cause or contribute to or are likely to cause or contribute to air pollution which endangers the public health or welfare." Such standards were promulgated for new and certain in-use subsonic aircraft engines on July 17, 1973 (38 FR 19088) and appear in 40 CFR part 87.

In the preamble to these standards it was stated that, "EPA intends to monitor closely the development of this technology through programs sponsored both by other Federal agencies and by industry. If it should become evident that the standards as promulgated cannot be achieved by the technology approaches explored in these programs, additional rulemaking action wil be considered to ensure that the best technology available is reflected in the standards."

Standards limiting emissions from in-use subsonic aircraft turbine engines rated at greater than 29,000 pounds of thrust were proposed on July 17, 1973 (38 FR 19050). On September 10, 1974, EPA announced that the comment period for these proposed standards would remain open until more information had become available bearing on the technology for controlling emissions to the proposed levels (39 FR 32631).

On November 7, 1975 the Environmental Protection Agency published a Notice of Public Hearing (40 FR 52082) to obtain comments from interested parties on the proposed emission standards for in-use aircraft (38 Fr 19050). In addition the hearings were opened to the subject of the status of the development of technology necessary for compliance with certain emission standards applicable to new air craft turbine engines (40 CFR part 87). The comments on the status of technology developments along with subsequent submittals of supplemental data were analyzed and reported in the EPA report "Aircraft Technology Assessment—Status of the Gas Turbine Program," December 1976, which forms part of the basis for this proposed rulemaking. (Copies of this report and all reports subsequently cited in reference are available for inspection in the EPA Public Information Reference Unit.)

Environmental Impact of Aircraft Emissions

Prior to promulgating the present aircraft standards (40 CFR part 87) an air quality analysis was performed which concluded that "airports and aircraft are now, or are projected to be, significant sources of emissions of carbon monoxide, hydrocarbons, and nitrogen oxides in some of the air quality control regions in which the national ambient air quality standards are being violated, as well as being significant sources of smoke; and therefore that attainment and maintenance of the national ambient air quality standards and reduced impact of smoke emissions requires that aircraft and aircraft engines be subject to a program of control compatible with their significance as polution sources. Accordingly, the Administrator has determined that emissions from aircraft and aircraft engines should be reduced to the extent practicable with present and prospective technology ("Aircraft Emissions: Impact on Air Quality and Feasibility of Control", EPA 1972).

Recent studies have concluded that the air quality impact at major air terminals is much more significant than that at the smaller, general aviation airports and further, that the major aircraft contributors at the major air terminals are the commercial aircraft and not general aviation aircraft ("Aircraft Emissions at Selected Airports 1972-1985", EPA AC 77-01, January 1977, and "An Assessment of the Potential Air Quality Impact of General Aviation Aircraft Emissions", Bruce C. Jordan, EPA, June 6, 1977).

For large general aviation airports where general aviation traffic is a significant fraction of the total, it was found that CO approaches the ambient air quality standard only at the runway where people are exposed for only brief periods and therefore cannot be construed to be a problem. HC and NOx emissions were found to be less than 100 tons per year at any general aviation airport. Therefore, it is clear that emissions from general aviation airports do not provide strong justification for a program of Federal standards applicable to general aviation aircraft.

On the other hand, emissions from major air terminals dominated by commercial traffic continue to appear sufficient in magnitude to justify Federal standards applicable to commercial aircraft. At major terminals, the annual emissions due to aircraft alone are of the order of thousands of tons per year for each gaseous pollutant, while in comparison, a stationary source is defined as major under new section 302(j) of the Clean Air Act if it emits 100 tons per year or more of any pollutant. (42 U.S.C. 7602(j), as added by section 301(a), Pub. L. 95-95, 91 Stat. 769-770).

However, the air quality justification for control of airport NOx emissions has been questioned. ("Potential Impact of NOx Emissions from Commercial Aircraft on NO2 Air Quality," Bruce C. Jordan, EPA, November 15, 1977). Therefore, a study has been planned which will incorporate the up-to-date aircraft emissions estimates referenced above, the most recent meteorological information, and the most advanced available mathematical modelling techniques for prediction of ambient air concentrations of pollutants in the airport environment. This study will be carried out jointly by the EPA and the Federal Aviation Administration and is expected to be completed in 1979.

Accordingly, promulgation of amended NOx standards based on this proposal will be deferred until completion of the FAA-EPA study so that such action can be based on the best and most current technical data bearing on the impact of aircraft operations on urban ambient air quality. Although the EPA expects to promulgate revised HC and CO standards in 1978, to avoid production lead-time problems that could result from unanticipated delay, an announcement of a 2 year deferral in the implementation date for emissions standards having an implementation date of January 1, 1979, is being published concurrently with this proposal.

It should be pointed out that, notwithstanding the announced delay in final promulgation of these proposed standards, it is expected at this time that the standards will be promulgated at the emissions levels and on the schedules which are proposed herein. It is recommended that all parties affected by these proposed standards make their individual plans on this assumption.

Cost Impact

On the basis of the information available at this time from aircraft industry sources, the EPA Office of Mobile Source Air Pollution control (OMSAPC) estimated average costs of these proposed standards to be:

Rule	Cost per engine	Increase in price per engine (percent)
1981 NME*	$90,000	6
1984 NME	110,000	10
1985 retrofit with 1981 NME	44,000	7

*Newly manufactured engines.

These costs are considered by OMSAPC to represent an upper limit, and the actual costs may be lower. This translates into the following cost effectiveness (cost of control required per ton of pollutant eliminated) values:

Rule	In dollars per ton		
	HC	CO	NOx
1981 NME	560	220	
1984 NME	560	220	**1,316
1985 retrofit with 1981 NME	590	170	

**Excluding probable maintenance penalty of undetermined size.

The cost of control for the newly certified engine standards is expected to be lower due to a broader distribution of development costs. These costs and cost effectiveness values for HC and CO are in the same range as those of other pollution control strategies being implemented or considered for implementation by the Agency at this time. The NOx value is higher than costs associated with other NOx strategies being implemented (and may be even higher as more information on maintenance costs is obtained), but until a more comprehensive analysis can be performed based on more detailed comprehensive cost estimates, relative cost effectiveness alone cannot be a basis for rejecting aircraft NOx control. The basis for these costs are outlined in EPA Report SDSB TSR AC 77-02 "Cost-Effectiveness Analysis of the Proposed Revisions in the Exhaust Emission Standards for New and In-Use Gas Turbine Engines Based on Industry Cost Estimates."

Returning to general aviation aircraft, although the total HC emissions at the most active general aviation airports approach the level generally considered to describe a major source (100 tons HC per year), control would not be as cost effective as other mobile source HC control strategies. The cost of HC control from general aviation aircraft is estimated at $2,000 per ton of HC as compared to $500–$1,400 to achieve the .41 g/mile light-duty vehicle HC standard. (If the total national costs were assigned to the HC reduction achieved in specific air quality regions having long term oxidant problems, the cost effectiveness values would be far higher).

The cost data from which the foregoing cost effectiveness figures were derived are limited and were based solely on information obtained from the affected industry. Information is hereby requested on the detailed costs to comply with the proposed regulations, including all the assumptions and methodology used in the analysis, for engine manufacturers, aircraft manufacturers, and air carriers.

Major Decision Issues

Should the Emissions Standards Applicable to General Aviation Aircraft be Retained? The preceding discussions of air quality impact and cost efectiveness of control, in view of the fact that resources available to the EPA for the pursuit of achievement of the national air quality standards are substantially limited, suggest that further EPA efforts to impose emission controls on general aviation aircraft engines do not rank sufficiently high in priority to merit their being pursued at this time.

Emissions impact studies at airports have shown that the most significant contribution to airport pollution is due to commercial turbine powered aircraft. At the major air terminals this contribution ranged from 80 to 99 percent of the total aircraft pollution burden. However, at smaller airports where non-commercial aircraft are flown, the total pollutants produced are not sufficient to justify the costs required to reduce them. Therefore, it was concluded that the most cost effective control strategy for aircraft would be to control only those aircraft engines which cause the most significant pollution load, namely commercial aircraft engines.

Are the Levels of the Present Standards Applicable to Commercial Aircraft Appropriate? In determining appropriate levels for standards, consideration was given to air quality needs, technical feasibility, and comparative cost effectiveness.

The EPA technology assessment of newly manufactured engines concluded that the T2 class HC and CO standards were technically feasible for engines with rated thrust above 20,000 pounds. The smaller T2 engines and some T1 engines are subject to certain technological constraints requiring standards that are available with engine size, the smallest engines tending to have the highest emission rates. After consideration of the limited overall air quality impact of such engines, it was determined that control of engines less than 6,000 pounds rated thrust was not justifiable at this time.

The control of NOx is more complex and more extensive development is required. The technology developed under NASA sponsorship which is considered reasonable to implement will not achieve the current levels and a relaxation of the newly manufactured engine NOx levels by 30 percent is necessary.

The question arose whether it is cost effective and necessary to control NOx emissions from the small to medium sized newly manufactured commercial engines (i.e., less than 20,000 pounds of thrust). The most important factor in considering this question is the air pollution contribution of the JT8D engine (T4 class). Initially, it was thought that the JT8D family would cease production in the near future to be replaced by a newer, larger engine (over 20,000 pounds of thrust). This would have made the NOx contribution from this group relatively less important and certainly much less cost effective. Strong concerns have been expressed to EPA by the manufacturer of the JT8D engine (Pratt and Whitney) and by one of their customers (Douglas Aircraft) that publication of a proposal for NOx standards applicable to growth versions of the JT8D engine rated at above 20,000 pounds thrust might deter potential airline customers from ordering an advanced version of the Douglas DC9 aircraft which has recently been announced. These companies have stated that they believe the airlines would instead order competitive aircraft powered by the current, below 20,000 pounds thrust, version of the JT8D engine.

Recent information from Pratt and Whitney; however, forecasts a consid-

erable future market for new versions of the JT8D of less than 20,000 pounds of thrust as well as of growth versions of greater than 20,000 pounds of thrust. This suggests two alternative actions that may be appropriate, the first to control NOx from the small to medium sized newly manufactured engines (principally the JT8D), and second, to abandon NOx control of the T4 class altogether (regardless of thrust).

EPA has elected to control NOx for all commercial engines over 6,000 pounds thrust principally because of the need for control of the JT8D engine as reflected in its market forecast. Also, consideration was given to the need for equity between competing engines (in the context of growth versions of the JT8D) and to the expected availability of effective NOx control technology for the JT8D and other small to mid-sized engines. New engines recently announced by other manufacturers, such as the Rolls Royce RB. 432, would also be included in this action.

It may be argued that the less fuel efficient older design engines such as the JT8D have not yet been demonstrated to be capable of meeting NOx standards as low as have been demonstrated with the more efficient modern engines. While it is true that NASA sponsored research on the JT8D engine did succeed in achieving substantial reductions, the levels were not low enough to comply with the proposed standards. On the other hand, research on NOx control for the JT8D combustor was terminated at a relatively early stage and it is not known whether continued efforts to reduce NOx emissions might not have achieved greater success if the research had been continued through the engine demonstration stage, as was the case for the two engines whose demonstrated performance provides the technological basis for the NOx standard proposed herein. Comments are specifically invited on the achievability of this standard for the JT8D and for all other affected engines for which NOx control technology has not yet been demonstrated.

The Agency recognizes that the issue of requiring control of NOx from newly manufactured engines, regardless of their size, remains controversial and may not currently be amenable to resolution on the basis of available data. This factor arises because the currently promulgated ambient air quality standard for NO2 is expressed in terms of an annual average of 100 micrograms per cubic meter; in those terms, the contribution of aircraft to degradation of ambient air quality may no be large. However, the 1977 amendments to the Clean Air Act have directed the Agency to promulgate by August of 1978 and ambient air quality standard for NO2 over a period of not more than three hours, unless it is determined that such a standard is not needed to protect public health (Section 109(C) as amended). Quite clearly, the potential for aircraft NOx emissions to contribute significantly to violation of such a short-term NO2 ambient air quality standard is substantially higher than is the estimated contribution of aircraft to violation of the current annual standard. Thus the probability is high that in terms of the anticipated short-term NO2 standard the need for control of NOx emissions from aircraft will be substantially greater than such need may be in terms of the annual standard. For that reason, in anticipation of a short-term NO2 standard, the Agency is proposeing the imposition of the foregoing NOx standards. The Agency is specifically soliciting public comment on the anticipated impact on the violation of short-term ambient air quality standards that would be expressed in terms of a one hour standard with values ranging from 100 micrograms to 500 micrograms per cubic meter. The above ranges do not reflect a decision on the part of the Agency to set the short term NO2 standard at either extreme, but rather represent the range within which it at this time appears likely that the ultimate short-term NO2 standard may be established. The Agency also solicits comment on the technical feasibility and cost-effectiveness of controlling aircraft emissions to the proposed emission levels, and on the cost-effectiveness of such emission standards in terms of the overall contribution of aircraft to localized violations of an anticipated short term NO2 ambient air quality standard.

The Agency intends to defer, until after promulgation of the short-term ambient NO2 standard in August 1978 and after completion of the joint EPA/FAA airport air quality analysis discussed earlier, promulgation of the NOx standard based on this proposal.

Are the Present Compliance Dates for the Standards Appropriate? The manufacturers have claimed that insufficient lead time exists to introduce emission controls into production engines by the current January 1, 1979 compliance date. The majority of the commenters claimed that an additional three years would be required; that is, implementation on January 1, 1982. Analysis of the submitted information revealed that the industry has taken a highly conservative position with respect to time allotted for certain developmental elements, particularly service evaluation, especially when compared with past programs. It is the EPA's position that this schedule is unnecessarily long and implementation of initial emission controls need not be delayed beyond January 1, 1981 for newly manufactured engines. The NOx controls require significantly more complex hardware changes and are not as well developed as the HC and CO control systems. Therefore, the NOx system will take an additional three years resulting in implementation on January 1, 1984.

There has been little additional information or criticism submitted to EPA on lead time requirements for newly certified engines since publication of those standards. In view of the availability of adequate NOx control in 1984 and in consideration of the span of time between this date and the date of initial HC and CO control, an implementation date of January 1, 1984 for newly certified engines is proposed.

Should Special Provisions be Made for Low Production or Old Engines? The Agency received numerous comments that engines which are nearly the end of their production life would be terminated prematurely because there would be insufficient future sales to justify incorporating emission controls. As well, there exist old engine models which would continue to be produced in small numbers well beyond the implementation date of the standards; however, technology does not exist for these engines to reduce emissions sufficiently. Since all engines in this situation are produced for general aviation applications, the proposed rulemaking, which would impose no standards for these engines, will resolve this problem.

Is the Proposed In-Use Aircraft Engine Retrofit Program Appropriate? Comments on the proposed in-use engine standards generally fall into two categories. First, the standards should be set at levels which can be achieved with relatively non-complex hardward changes and, second, adequate time should be allowed for implementation of the retrofit of aircraft engines. The technology assessment study revealed that the control systems developed for compliance of large engines (greater than 29,000 pound thrust) to the newly manufactured engine HC and CO standards could be installed in in-use engines. Additionally, it was determined that the HC and CO control system for the JT8D engine could also be retrofitted without significant problems. Since the JT8D engine is used extensively in the U.S. commercial aircraft fleet any reasonable reductions which can be achieved from this engine would have a significant improvement on air quality in the near term. For example, the originally proposed in-use standard provided a CO reduction of 37 percent at JFK airport in 1985; retrofitting the JT8D engines increases the reduction to 50 percent. Thus the newly manufactured engine HC and CO standards are considered appropriate for existing in-use engines. Since no NOx control

scheme has yet been developed which can be readily retrofitted other than the costly water injection system, it was determined that a NOx retrofit standard for existing in-use aircraft engines is inappropriate at this time.

It was generally agreed among the commenters that a period of four years will be required to incorporate the necessary changes in the commercial aircraft fleet. Therefore projecting that the control systems will be available for application in 1981, the compliance date for in-use aircraft engines is proposed for January 1, 1985.

Has a Margin for Variability Been Included in Setting the Standards? Engine-to-engine variations, test-to-test variations and exhaust measurement uncertainties make it likely that the measured emissions performance of each aircraft gas turbine engine will be different. Manufacturers have stated that allowances should be provided for such variation in setting the standards. When the standards were originally established, technology had not been demonstrated which would achieve the required level of control. Subsequent technical evaluation of the feasibility of achieving the stated levels with the technology which has developed resulted in a determination that the levels could be achieved and that sufficient margin exists to allow for normal variability. Thus, the standards are to be considered upper limits with respect to compliance testing and manufacturers must set their design goals sufficiently below the standards to account for variability.

How Should the Idle Power Setting be Specified? Comments stated that the present definition of the idle power set point for compliance testing was ambiguous and inequitable and should be replaced with a clearer definition such as a fixed power level.

The compliance test procedure requires that emissions be measured at four power points, including idle. The procedure allows the manufaturer to specify the idle power setting while the remaining power points are set at prescribed levels. The intent behind this approach is to simulate the emissions produced by an engine in actual use. EPA has concluded that no single value will truly represent satisfactorily the in-use idle point of all engines and that the total cycle HC and CO emissions are highly dependent on the idle power setting selected. Therefore, to yield emission measurements representative of what can be expected from a given engine when operated at an airport it is necessary that the test idle point be set at the value used in the field.

Therefore, the "manufacturer's recommended idle" definition is expanded to explicitly state that the engine be tested at the minimum idle set point for each particular engine with simulation permitted of minimum accessory influences experienced by the engine when operated in the idle mode. This approach is equitable and eliminates much of the ambiguity problem. In addition, the enforcement of the in-use engine standards is simplified in that it is clear that engines must be operated at or above the certified idle level to insure compliance with the HC and CO standards.

Is the Parameter Presently Used for Specifying the Emission Standards Appropriate? The EPA has received comments that the controlling parameter (i.e., the dimensions of the standards) is not appropriate in that it incorporates factors outside the control of the combustor design engineer. These commenters suggest the use of the emission index (EI) is more appropriate. The EI describes the pollution produced relative to the amount of fuel burned. As such, standards based on the EI would control only the combustor design with the total engine pollution dependent upon the fuel efficiency of the engine. For engines of equal power the one with the greatest fuel consumption would be allowed to produce the greatest pollution. The EPA parameter (EPAP), conversely, describes the total pollution produced relative to the useful work performed. The EPA parameter is considered equitable and best represents the engine pollution when operated at an airport. Therefore, its continued use is proposed.

However, in order to simplify the parameter for easier use in air quality analysis and for other technical reasons which make it more appropriate, the EPA technical staff has recommended the use of the rated thrust, rather than the total impulse, as the normalizing useful work factor. This change is being proposed and has essentially no impact on the stringency of the standards.

Should NOx Limits Be Corrected for Engine Pressure Ratio? An adjustment to the NOx standard was requested in the comments to account for the unavoidable NOx penalties which arise from differences in the cycle pressure ratios between different engine models. The issue is different for existing designs and for future designs. For future designs, it is claimed that a failure to account for the adverse pressure effect on NOx will lead to a degradation in fuel economy because the designer will be forced to select a pressure level for the engine which is less than that which is most desirable from a fuel economy point of view. On the other hand, the development of ultra low NOx combustors combined with the fuel economy improvements may compensate for the tendency towards higher NOx arising from the higher pressure ratio. Thus, it appears premature to conclude that a pressure correction is necessary for NOx emissions to avoid compromising fuel economy in future engine designs. EPA has further concluded that it is better to promulgate equitable standards at an early point so that the selection and design of a new type of engine can be influenced by the emissions standards as a basic constraint, along with the other performance requirements which the engine must meet. The existence of the NOx standard as formulated is expected to influence the trend in engine design, but it will not dictate it. The EPA recognizes that in so dynamic a field as aircraft engine development it will be necessary, from time to time, to review existing emission standards for the purpose of determining their impact on the feasibility of utilizing technology that may not have been available when the standards were formulated. As a result of the current NASA work, or other future developments, technology may become available that for fuel consumption or other performance factors is clearly superior but that cannot meet promulgated emission standards. In that case all of the relevant issues will be reconsidered by EPA in the context of all technical and environmental data then available, and a decision made by the Administrator that is appropriate on the basis of the new information.

Considering next the problem of existing engine designs, a review of the progress of advanced technology combustors for reduced oxides of nitrogen reveals a wide range of emissions performance between competing engines which is attributable directly to differences in the cycle pressure ratio. The selection of the NOx standard should be based upon the performance of this advanced technology, but if the standard is selected high in order to accommodate the performance of the high pressure ratio engines, then the lower pressure ratio engines may comply without application of any advanced NOx technology, whereas if the standard is selected low reflecting the potential of the lower pressure ratio engines, then many of the higher pressure ratio engines will fail even utilizing the best demonstrated combustor technology.

A standard which permits higher emissions for high pressure ratio engines will force all existing engines to apply the best advanced technology that has been identified in order to achieve the required emissions levels and yet will not unduly penalize those engines which obtain high efficiency through high pressure ratios.

Are the Compliance Test Fuel Specifications Properly Defined? It has been brought to EPA's attention that the test fuel as now specified may change from time to time under the pressure of rising fuel costs and, in the

future, synthetically derived atlternative fuels. It is known that combustion pollutant levels in an engine are related to fuel properties and composition. This may cause difficulties with the continuous compliance requirement and with the establishment of technology capable of achieving the standards with fuels significantly different from those used to develop the technology. Comments on this matter are requested.

Should the EPA Limit the Applicability of the Standards to U.S. Aircraft Only and Look to ICAO to Control International Aircraft? Consistent with the stated policy for SST aircraft (41 FR 34723, August 16, 1976) EPA intends to cooperate fully with the ICAO in the development of international standards for control of emissions from all classes of aircraft. Nevertheless, in order to fulfill EPA's responsibility under the Clean Air Act, it is necessary to minimize emissions from aircraft of both United States and foreign registry. Moreover, to exempt foreign aircraft would be unfair to domestic air carriers. Therefore, these standards will apply to aircraft of foreign registry until such time as the ICAO has promulgated regulations of at least equivalent stringency. At that time consideration can be given to applicability of ICAO standards to aircraft of foreign registry while the EPA standards would continue to apply to aircraft of United States registry.

Section 231 of the Act provides that the Administrator shall hold a public hearing with respect to proposed aircraft emission standards. a notice of time, date, and place for the hearing will be published in the FEDERAL REGISTER in the near future. This hearing is intended to provide an opportunity for interested persons to state their views or arguments, or provide information relative to the proposed amendments to the standards.

In addition, interested parties may participate in this rulemaking by submitting written comments to the EPA at the address given above. All relevant material received during the comment period will be considered.

It is EPA's intention to assure all interested parties an opportunity to study all information which may become the basis for EPA's final action in this proceeding. Accordingly, the Agency will not consider in this rulemaking any material which cannot be made available to the public. Parties who wish to submit information in response to this Notice of Proposed Rulemaking are cautioned that EPA will not consider, but will return to the commentor any comments which are claimed, in whole or in part, to be confidential.

In accordance with provisions of section 307 of the Clean Air Act, a copy of all data, information, and documents on which this proposal relies, all public comments, the transcript of public hearings, and certain other documents will be available for inspection and copying between 8 a.m. and 4:30 p.m., Monday through Friday at the EPA Public Information Reference Unit, Room 2922 (EPA Library), 401 M Street SW., Washington, D.C. 20460 (Docket No. OMSAPC—78-1). As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services.

The EPA believes that the costs of these proposed amendments will be substantially less than the costs of the present standards. Consequently, the resulting new economic impact on the regulated industry is expected to be less than the impact of the regulations already promulgated. It may be that this document constitutes a regulation that will not result in major economic impacts. Economic Impact Assessments under Executive Orders 11821 and 11949 and under OMB Circular A-107 are required for "major" regulations and under section 317 of the Clean Air are required for aircraft emission standards and substantial revisions of such standards. Because the industry has itself indicated a desire for EPA to avoid further uncertainty by promptly publishing this proposal, EPA is publishing this proposal before completion of the economic impact assessment. This economic assessment will be completed in two steps. First, an assessment that does not include the effect of NOx control on the JT8D engine will be available in the very near future.

A second economic assessment, analyzing the effect of NOx control on the JT8D engine, will subsequently be completed. Upon completion, each assessment will be included in the public docket for this rulemaking. EPA will then publish a supplement to this Notice of Proposed Rulemaking, announcing the completion and availability of the assessment, evaluating the extent to which this proposal is supported by the assessment, and revising this proposal if required by the analysis in the assessment. The supplement will explain the extent to and manner in which the Administrator has considered the analysis contained in the assessment. The comment period will continue for at least 60 days after publication of the supplement. A revised economic impact assessment will also be placed in the docket concurrently with final promulgation of these amendments.

Dated: March 10, 1978.

DOUGLAS M. COSTLE,
Administrator.

In Title 40 of the Code of Federal Regulations it is proposed to revise Part 87 to read as follows:

Subpart A—General Provisions

Sec.
87.1 Definitions.
87.2 Abbreviations.
87.3 General requirements.
87.4 Test conditions.
87.5 Special test procedures.
87.6 Aircraft Safety.

Subpart B—Engine Fuel Venting Emissions (New and In-Use Aircraft Gas Turbine Engines)

87.10 Applicability.
87.11 Standard for fuel venting emissions.

Subpart C—Exhaust Emissions (New Aircraft Gas Turbine Engines)

87.20 Applicability.
87.21 Standards for exhaust emissions.

Subpart D—Exhaust Emissions (In-Use Aircraft Gas Turbine Engines)

87.30 Applicability.
87.31 Standards for exhaust emissions.

Subpart E [Reserved]

Subpart F [Reserved]

Subpart G—Test Procedures for Engine Exhaust Gaseous Emissions (Aircraft and Aircraft Gas Turbine Engines)

87.60 Introduction.
87.61 Turbine fuel specifications.
87.62 Test procedure (propulsion engines).
87.63 [Reserved]
87.64 Sampling and analytical system for measuring exhaust emissions.
87.65 Information to be recorded.
87.66 Calibration and instrument checks.
87.67 Sampling procedures.
87.68 Test run.
87.69 Chart reading.
87.70 Calculations.
87.71 Compliance with emission standards.

Subpart H—Test Procedures for Engine Smoke Emissions (Aircraft Gas Turbine Engines)

87.80 Introduction.
87.81 Fuel specifications.
87.82 Sampling and analytical system for measuring smoke exhaust emissions.
87.83 Information to be recorded.
87.84 Calibration and instrument checks.
87.85 Test procedures.
87.86 Test run.
87.87 Determination of SN.
87.88 Calculations.
87.89 Compliance with emission standards.

Subpart I [Reserved]

Subpart J—Temporary Exemption From Aircraft Emission Standards (Fuel Venting and Smoke)

87.101 Application for temporary exemption.
87.102 30-day suspension of fuel venting and smoke standards.

APPENDIX A.—INSTRUMENTATION (AIRCRAFT GAS TURBINE ENGINE MEASUREMENTS).

APPENDIX B [RESERVED]

AUTHORITY: Secs. 231, 301, Clean Air Act, as amended (42 U.S.C. 7571, 7601, formerly 42 U.S.C. 1857f-9, 1857g).

Subpart A—General Provisions

§ 87.1 Definitions.

(a) As used in this part, all terms not defined herein shall have meaning given them in the Act:

"Act" means the Clean Air Act, as amended (42 U.S.C. 7401 et seq.)

"Administrator" means the Administrator of the Environmental Protection Agency and any other officer or employee of the Environmental Protection Agency to whom the authority involved may be delegated.

"Aircraft" means any airplane for which a U.S. standard airworthiness certificate or equivalent foreign airworthiness certificate is issued.

"Aircraft engine" means a propulsion engine which is installed in or which is manufactured for installation in an aircraft.

"Aircraft gas turbine engine" means a turboprop, turbofan, or turbojet aircraft engine.

"Calibration gas" means a gas of known concentration which is used to establish the response curve of an analyzer.

"Class P2" means all aircraft turboprop engines.

"Class T1" means all aircraft turbofan or turbojet engines except engines of Class T5 of rated power less than 35,600 newtons thrust.

"Class T2" means all turbofan or turbojet aircraft engines except engines of Class T3, T4, and T5 of rated power of 35,600 newtons thrust or greater.

"Class T3" means all aircraft gas turbine engines of the JT3D model family.

"Class T4" means all aircraft gas turbine engines of the JT8D model family.

"Class T5" means all aircraft gas turbine engines employed for propulsion of aircraft designed to operate at supersonic flight speeds.

"Commercial aircraft engine" means any aircraft engine used by an air carrier, foreign air carrier, supplemental air carrier, or charter air carrier engaging in: (1) Interstate or overseas air transportation, (2) foreign air transportation, or (3) intrastate air transportation with large aircraft.

"Commercial aircraft gas turbine engine" means a turboprop, turbofan, or turbojet commercial aircraft engine.

"Emission measurement system" means all of the equipment necessary to transport and measure the level of emissions. This includes the sample system and the instrumentation system.

"Engine pressure ratio (EPR)" means the ratio of the mean total pressure at the turbine exit plane to the mean total pressure at the fan/low pressure compressor entrance plant.

"Exhaust emissions" means substances emitted to the atmosphere from the exhaust discharge nozzle of an aircraft or aircraft engine.

"Fuel venting emissions" means all raw fuel, exclusive of hydrocarbons in the exhaust emissions, discharged from aircraft gas turbine engines during all normal ground and flight operations.

"Instrumentation system" means the system which consists of the analytical instruments necessary to measure the level of emissions plus any required support equipment.

"In-use aircraft gas turbine engine" means an aircraft gas turbine engine which is in service.

"New aircraft turbine engine" means an aircraft gas turbine engine which has never been in service

"Newly certified aircraft gas turbine engine" means an aircraft gas turbine engine which is originally type-certified on or after the effective date of the applicable emission standard.

"Oxides of nitrogen" means the sum of the amounts of the nitric oxide and nitrogen dioxide contained in a gas sample as if the nitric oxide were in the form of nitrogen dioxide.

"Power setting" means the power or thrust output of an engine in terms of newtons thrust for turbojet and turbofan engines and shaft power in terms of kilowatts for turboprop engines.

"Rated compressor discharge temperature (rT3)" means the combustor inlet total temperature achieved by an engine operating at rated output.

"Rated output (rO)" means the maximum power/thrust available for takeoff at standard day conditions as approved for the engine by the Federal Aviation Administration.

"Rated pressure ratio (rPR)" means the ratio between the combustor inlet pressure and the engine inlet pressure achieved by an engine operating at rated output.

"Reference day conditions" means the reference ambient conditions to which the gaseous emissions (HC, CO, CO_2, NOx and smoke) are to be corrected. The reference day conditions are as follows: Temperature=15° C, specific humidity=0.00629 kilograms of water per kilogram of dry air, and pressure=101325 Pa.

"Sample system" means the system which provides for the transportation of the gaseous emission sample from the sample probe to the inlet of the instrumentation system.

"Shaft power" means only the measured shaft power output of a turboprop engine.

"Smoke" means the matter in exhaust emissions which obscures the transmission of light.

"Smoke number (SN)" means the dimensionless term quantifying smoke emissions.

"Span gas" means a gas of known concentration which is used routinely to set the output level of an analyzer.

"Standard day conditions" means standard ambient conditions as described in the United States Standard Atmosphere, 1962, (i.e., temperature=15° C, specific humidity=0.00 Kg H_2O/Kg dry air, and pressure=101325 Pa).

"Taxi/idle (in)" means those aircraft operations involving taxi and idle between the time of landing roll out and final shutdown of all propulsion engines.

"Taxi/idle (out)" means those aircraft operations involving taxi and idle between the time of initial starting of the propulsion engine(s) used for the taxi and turn onto duty runway.

§ 87.2 Abbreviations.

The abbreviations used in this part have the following meanings in both upper and lower case:

abs.	Absolute.
ASA	American Standards Association.
ASTM	American Society for Testing and Materials.
C.	Celsius.
cc.	Cubic centimetre.
CO_2	Carbon dioxide.
CO	Carbon monoxide.
EPR	Engine pressure ratio.
FAA	Federal Aviation Administration, Department of Transportation.
FID	Flame ionization detector.
H	Specific humidity, kilograms of water per kilogram of dry air.
H/C	Hydrogen to carbon atomic ratio.
HC	Hydrocarbon(s).
Hg	Mercury.
hr.	Hour(s).
I.D.	Inside diameter.
J	Joule.
K	Kelvin.
LTO	Landing takeoff.
min.	Minute(s).
mm.	Millimetre(s).
mm. HgV.	Millimetre(s) of mercury, vacuum.
N	Newton(s).
N_1	First-stage rotor speed.
N_2	Second-stage rotor speed or nitrogen (as applicable).
N_3	Third-stage rotor speed.
NO	Nitric oxide.
NO_2	Nitrogen dioxide.
NOx	Oxides of nitrogen, NO and NO_2.
NDIR	Nondispersive infrared analyzer.
O_2	Oxygen.
O_3	Ozone.
P	Pressure.
Pa	Pascal(s).
p.p.m.	Parts per million by volume.
p.p.m.C	Parts per million carbon.
PT_7	Total pressure at station 7.
rO	Rated output.
rPR	Rated pressure ratio.
r.p.m.	Revolutions per minute.
rT_3	Rated compressor discharge temperature.
sec.	Second(s).
SP	Shaft power.
SN	Smoke number.
T	Temperature, degrees Kelvin.
TIM	Time in mode.
TT_7	Total temperature at station 7.
W	Watt(s).
°	Degree.
%	Percent.

§ 87.3 General requirements.

(a) This part provides for the approval or acceptance by the Administrator or his agents of testing and sampling methods, analytical techniques, and related equipment not identical to those specified in this

part. Before he approves or accepts any such alternate, equivalent, or otherwise nonidentical procedures or equipment, the Administrator shall consult with the Secretary of Transportation in determining whether or not the action requires rulemaking under sections 231 and 232 of the Clean Air Act, as amended, consistent with the Secretary's responsibilities under section 232 of the Act. (42 U.S.C. 7571, 7572)

(b) Under section 232 of the Act, the Secretary of Transportation issues regulations to insure compliance with this part and all amendments thereof.

(c) With respect to aircraft of foreign registry, these regulations shall apply in a manner consistent with any obligation assumed by the United States in any treaty, convention or agreement between the United States and any foreign country or foreign countries.

§ 87.4 Test conditions.

The complete engine as configured for final acceptance testing, including all accessories which might reasonably be expected to influence emissions to the atmosphere including auxiliary gearbox-mounted components required to drive aircraft systems and service air bleed, shall be functional for all testing in this part.

§ 87.5 Special test procedures.

The administrator may, upon written application by a manufacturer or operator of aircraft or aircraft engines, prescribe test procedures for any aircraft or aircraft engine that is not susceptible to satisfactory testing by the procedures set forth herein. Prior to taking action on any such application, the Administrator shall consult with the Secretary of Transportation.

§ 87.6 Aircraft safety.

The provisions of this part will be revised if at any time the Secretary of Transportation determines that an emission standard cannot be met within the specified time without creating a safety hazard.

Subpart B—Engine Fuel Venting Emissions (New and In-Use Aircraft Gas Turbine Engines)

§ 87.10 Applicability.

The provisions of this subpart are applicable to each new aircraft gas turbine engine of classes T2, T3, T4, and T5 manufactured on or after January 1, 1974, and all in-use aircraft gas turbine engines of classes T2, T3, T4, and T5 beginning January 1, 1974, and each new aircraft gas turbine engine of Classes T1 and P2 manufactured on or after January 1, 1975 and all in-use aircraft gas turbine gengines of Classes T1 and P2 beginning January 1, 1975.

§ 87.11 Standard for fuel venting emissions.

(a) No fuel venting emissions shall be discharged into the atmosphere from any new or in-use gas turbine engine subject to the subpart. This paragraph is directed at the elimination of intentional discharge to the atmosphere of fuel drained from fuel nozzle manifolds after engines are shut down and does not apply to normal fuel seepage from shaft seals, joints, and fittings.

(b) Conformity with the standard set forth in paragraph (a) of this section shall be determined by inspection of the method designed to eliminate these emissions.

Subpart C—Exhaust Emissions (New Aircraft Gas Turbine Engines)

§ 87.20 Applicability.

The provisions of this subpart are applicable to all aircraft gas turbine engines of the classes specified beginning on the dates specified.

§ 87.21 Standards for exhaust emissions.

(a) Exhaust emissions of smoke from each new aircraft gas turbine engine of class T4 manufactured on or after January 1, 1974, shall not exceed: Smoke number of 30.

(b) Exhaust emissions of smoke from each new aircraft gas turbine engine of class T2 and of rated output of 129,000 newtons thrust or greater, manufactured on or after January 1, 1976 shall not exceed: $SN=79\ (rO)^{-0.265}$ (rO is in kilonewtons).

(c) Exhaust emission of smoke from each new aircraft gas turbine engine of class T3 manufactured on or after January 1, 1978 shall not exceed: Smoke number of 25.

(d) Exhaust emissions from each commercial aircraft gas turbine engine of the classes and rated output ranges specified below manufactured on or after the dates indicated shall not exceed:

(1) Classes T1, T2, T3, T4 engines equal to or greater than 27,000 newtons rated output but less than 90,000 newtons rated output (January 1, 1981):

(i) Hydrocarbons: . . . $26.510\times10^{-0.0\ 00837\times rO}$ grams/kilo- newton (rO is in kilonewtons).

(ii) Carbon monoxide (January 1, 1981): . . . $169.47\times10^{-0.007463\times rO}$ grams/kilonewton (rO is in kilonewtons).

(iii) Oxides of nitrogen (January 1, 1984): . . .

(*a*) 33.0 grams/kilonewton for rPR less than or equal to 25; or

(*b*) 33.0 $(rPR/25)^{0.5}$ exp $[rT3/288.15-2.774]$ grams/kilonewton for rPR greater than 25.

(2) Classes T2, T3, and T4 engines equal to or greater than 90,000 newtons rated output:

(i) Hydrocarbons (January 1, 1981): . . . 6.7 grams/kilonewton.

(ii) Carbon monoxide (January 1, 1981); . . . 36.1 grams/kilonewton.

(iii) Oxides of nitrogen (January 1, 1984): . . .

(*a*) 33.0 grams/kilonewton for rPR less than or equal to 25; or

(*b*) 33.0 $(rPR/25)^{0.5}$ exp $[rT3/288.15-2.774]$ grams/kilonewton for rPR greater than 25.

(3) Class T5 (January 1, 1980):

(i) Hydrocarbons: . . . 30.7 grams/kilonewton.

(ii) Carbon monoxide: . . . 237.0 grams/kilonewton.

(iii) Oxides of nitrogen: . . . 70.8 grams/kilonewton.

(e) Smoke exhaust emissions from each aircraft gas turbine engine of the classes specified below manufactured on or after the dates indicated shall not exceed:

(1) Classes T1, T2, T3, T4 (January 1,dgr1981):lon. . . $SN=79(r$ kilonewtons).

(2)
$SN=277(rO)^{-0.260}$ (rO is in kilowatts).

(3)
$SN=79(rO)^{-0.260}$ (rO is in kilonewtons).

(f) Exhaust emissions from each newly certified commercial aircraft gas turbine engine of the classes and rated output ranges specified below manufactured on or after January 1, 1984, shall not exceed:

(1) Classes T1, T2, T3, T4 engines equal to or greater than 27,000 newtons rated power:

(i) Hydrocarbons: . . . 3.3 grams/kilonewton.

(ii) Carbon monoxide: . . . 25.0 grams/kilonewton.

(iii) Oxides of nitrogen: . . . 33.0 grams/kilonewton.

(2) Class T5:

(i) Hydrocarbons: . . . 7.8 grams/kilonewton.

(ii) Carbon monoxide: . . . 61.0 grams/kilonewton.

(iii) Oxides of nitrogen: . . . 39.0 grams/kilonewton.

(3) Class P2 engines equal to or greater than 2000 kilowatts rated output:

(i) Hydrocarbons: . . . 0.045 grams/kilowatt.

(ii) Carbon monoxide: . . . 0.34 grams/kilowatt.

(iii) Oxides of nitrogen: . . . 0.45 grams/kilowatt.

(g) The standards set forth in paragraphs (a), (b), (c), (d), (e), and (f) of this section refer to a composite gaseous emission sample representing the operating cycles set forth in the applicable sections of Subpart G of this part, and exhaust smoke emissions emitted during operations of the engine as specified in the applicable sections of Subpart H of this part, and

measured and calculated in accordance with the procedures set forth in those subparts.

Subpart D—Exhaust Emissions (In-Use Aircraft Gas Turbine Engines)

§ 87.30 Applicability.

The provisions of this subpart are applicable to all in-use aircraft gas turbine engines certified for operation within the United States of the classes specified beginning on the dates specified.

§ 87.31 Standards for exhaust emissions.

(a) Exhaust emissions of smoke from each in-use aircraft gas turbine engine of Class T4, beginning January 1, 1974, shall not exceed: Smoke number of 30.

(b) Exhaust emissions of smoke from each in-use aircraft gas turbine engine of class T2 and of rated output of 129,000 newtons thrust or greater, beginning Janaury 1, 1976, shall not exceed: $SN=79(rO)^{-0.265}$ (rO is in kilonewtons).

(c) Exhaust emissions of smoke from each in-use aircraft gas turbine engine of Class T3 shall not exceed a smoke number of 25. Each operator shall achieve compliance in accordance with the following schedule:

(1) One quarter of its operational Class T3 engines by January 1, 1981.

(2) One half of its operational Class T3 engines by January 1, 1983.

(3) All of its operational Class T3 engines by January 1, 1985.

This compliance schedule notwithstanding, Class T3 engines which do not meet a smoke number of 25 may continue to be operated if, under an approved plan, replacement engines or replacement airplanes have been ordered and are scheduled for delivery prior to January 1, 1985, but not after the dates specified in the plan. For the purpose of this paragraph, replacement engines are engines of a class different from Class T3 and have been shown to meet the smoke emission standards in this part appropriate to their class.

(d) Exhaust emissions from each in-use commercial aircraft gas turbine engine of classes T2 and T4, beginning January 1, 1985, shall not exceed:

(1) Engines equal to or greater than 53,000 newtons rated output but less than 90,000 newtons rated output:

(i) Hydrocarbons: . . . $26.510\times10^{-0.000537\times rO}$ grams/kilonewton (rO is in kilonewtons).

(ii) Carbon monoxide: . . . $169.47\times10^{-0.007402\times rO}$ grams/kilonewton (rO is in kilonewtons).

(2) Engines equal to or greater than 90,000 newtons rated output:

(i) Hydrocarbons: . . . 6.7 grams/kilonewton.

(ii) Carbon monoxide: . . . 36.1 grams/kilonewton.

(3) Smoke exhaust emissions from each engine equal to or greater than 53,000d ewtonsbegshall not exceed: $SN=79(rO)^{-0.265}$ (rO is in kilonewtons).

(e) The standards set forth in paragraphs (a), (b), (c), and (d) of this section refer to a composite gaseous emission sample representing the operating cycle set forth in the applicable sections of Subpart G of this part and exhaust smoke emissions emitted during operations of the engine as specified in the applicable sections of Subpart H of this part, and measured and calculated in accordance with the procedures set forth in those subparts.

(f) In addition to the requirements imposed by paragraphs (a), (b), (c), and (d) of this section, each in-use aircraft gas turbine engine shall not exceed the level of the standards applicable to such engine when it was new.

Subpart E [Reserved]

Subpart F [Reserved]

Subpart G—Test Procedures for Engine Exhaust Gaseous Emissions (Aircraft and Aircraft Gas Turbine Engines)

§ 87.60 Introduction.

(a) Except as provided under § 87.5, the procedures described in this subpart shall be the test program to determine the conformity of new and in-use aircraft gas turbine engines with the applicable standards set forth in this part.

(b) The test consists of operating the engine at prescribed power settings on an engine dynamometer (for engines producing primarily shaft power) or thrust measuring test stand (for engines producing primarily thrust). The exhaust gases generated during engine operation are sampled continuously for specific component analysis through the analytical train.

(c) The exhaust emission test is designed to measure hydrocarbons, carbon monoxide, carbon dioxide, and oxides of nitrogen concentrations, and to determine mass emissions through calculations during a simulated aircraft landing-takeoff cycle (LTO). The LTO cycle is based on time in mode data during high activity periods at major airports. The test for propulsion engines consists of at least the following five modes of engine operation: Taxi/idle (out), takeoff, climbout, approach, and taxi/idle (in). The mass emission for the modes are combined to yield the reported values.

(d) When an engine is tested for exhaust emissions on an engine dynamometer or test stand, the complete engine shall be used with all accessories which might reasonably be expected to influence emissions to the atmosphere installed and functioning. This includes auxiliary gearbox-mounted components required to drive aircraft systems and service air bleed as prescribed in § 87.62(a)(2).

§ 87.61 Turbine fuel specifications.

For exhaust emission testing, fuel meeting the specifications, ASTM D1655—latest version—Jet A, shall be used. Nonmetallic additives as specified in ASTM D1655—latest version—Jet A may be present. Additives used for the purpose of smoke suppression (such as organometallic compounds) shall not be present.

§ 87.62 Test procedure (propulsion engines).

(a)(1) The engine shall be tested in each of the following engine operating modes which simulate aircraft operation to determine its mass emission rates. Actual power setting, that when corrected to standard day conditions, corresponds to the following percentage of rated output, (rated output includes the reheat contribution and thrust augmentation due to water injection, if applicable):

Mode	Class P2	Class T1, T2, T3, or T4	Class T5
Taxi/idle (out)	(1)	(1)	(1)
Takeoff	100	100	100
Climbout	90	85	85
Descent	NA	NA	15
Approach	30	30	34
Taxi/idle (in)	(1)	(1)	(1)

[1] See subpt. (2) of this paragraph.

(2) The taxi/idle operating modes shall be carried out at the minimum idle power at which the engine can be operated in compliance with the applicable standards as specified by the manufacturer. Use of service air bleed and shaft power extraction to power auxiliary gearbox-mounted components required to drive aircraft systems is permitted at the minimum operating levels which can occur in use.

(b) Emission testing shall be conducted on warmed-up engines which have achieved a steady operating temperature.

§ 87.63 [Reserved]

§ 87.64 Sampling and analytical system for measuring exhaust emissions.

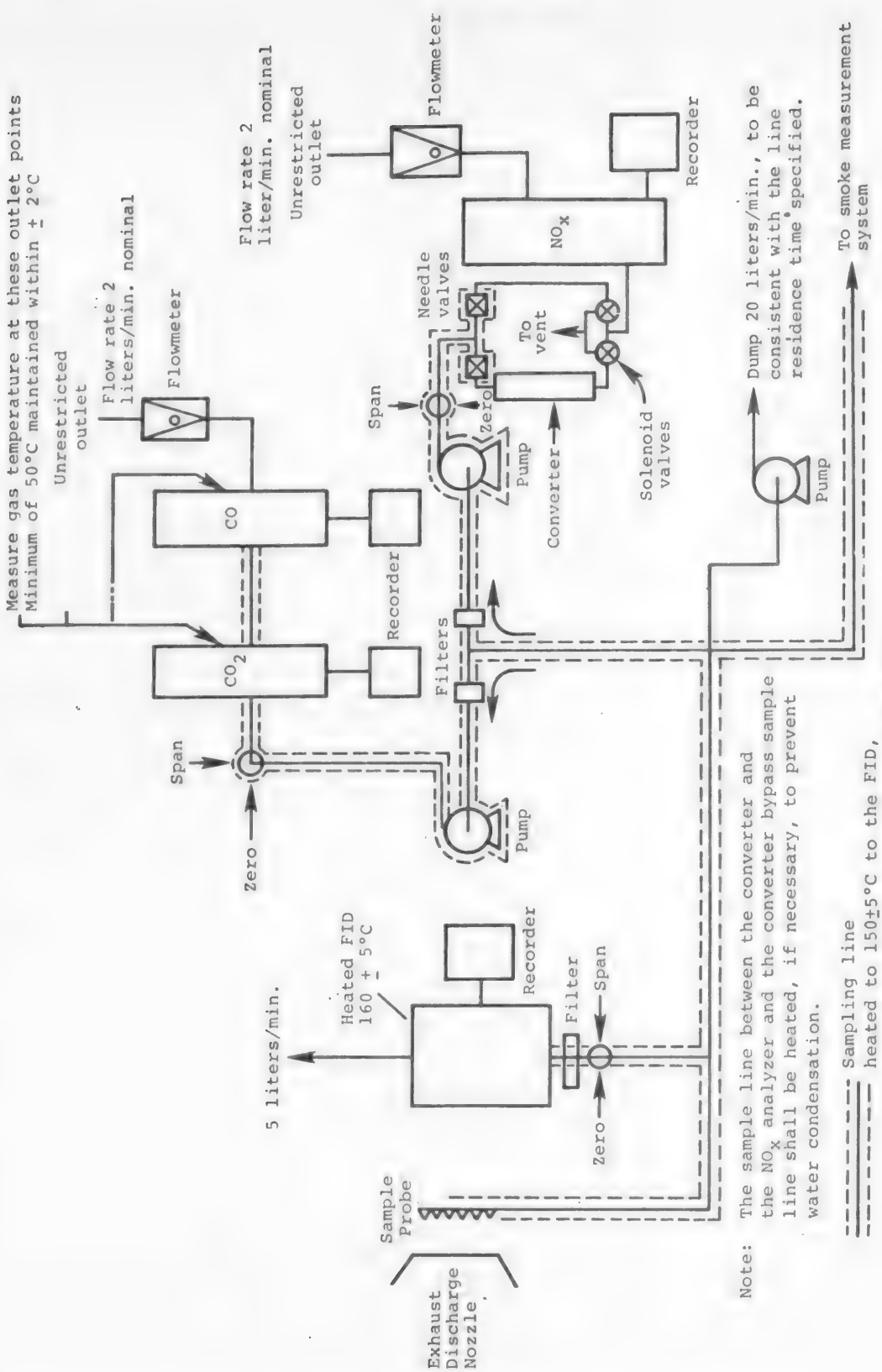


Figure 1 - SAMPLING SYSTEM AND INSTRUMENT ARRANGEMENT

(a) *Schematic drawing.* Figure 1 is a schematic drawing of the exhaust gas sampling and analytical system which shall be used for testing under the regulations in this subpart. Additional components such as instruments, valves, solenoids, pumps, and switches may be used to provide additional information and coordinate the functions of the component systems. Parallel installation of CO and CO_2 instruments are an acceptable alternate configuration of Figure 1.

(b) *Water removal devices.* No desiccants, dryers, water traps, or related equipment may be used to treat the exhaust sample flowing to the oxides of nitrogen measurement instrumentation. NOx instrument configuration must be such that condensation is avoided through the instrument. The extent of water vapor and carbon dioxide interference on the carbon monoxide analyzer shall be determined by passing a range of known concentrations of carbon dioxide and water vapor through the instrument and observing the response. If the effect is greater than 2 percent of measured CO levels, all subsequent measurements shall be corrected for these interferences.

(c) *Component description (exhaust gas sampling system).* The following components shall be used in the exhaust gas sampling system for testing under the regulations in this subpart.

(1) *Sampling probe.* (i) Probe design concept: The probe shall be made of stainless steel. If a mixing probe is used, all sampling holes shall be of equal diameter. Total probe orifice area shall be such that the principal pressure drop (at least 80 percent) through the probe assembly shall be taken at the orifice(s).

(ii) Probe orientation and sampling location:

(*a*) A minimum of 12 sampling points shall be used. Either mixing or individual probes are acceptable.

(*b*) A minimum of three different radial positions shall be used in each of four sampling quadrants.

(*c*) If the minimum of 12 sampling points are used, the points in circumferentially adjacent sampling areas shall be separated by at least 80° angular displacement. No two sampling points shall be separated in any direction by a distance less than 0.1 tailpipe radius or 0.1 annular height, as applicable. If the number of sampling points (n) is greater than 12, they shall be equal in number in each quadrant or sector and the minimum separations specified above shall be reduced by a factor=12/n.

(*d*) The axial sampling plane shall be as close to the plane of the exit nozzle as engine performance parameters permit, but in any case, shall be within one exit nozzle diameter of the exit plane, except for engine operation modes which employ reheat (afterburning).

(*e*) In all cases, the probe shall be designed to obtain a representative sample over the area of the entire exhaust nozzle, on both mixed fan engines and nonmixed fan engines as well as turbojet and turboprop engines.

(*f*) The multipoint probe shall be designed to minimize the errors due to pollutant stratification, whether the stratification is due to combustor design, mixing or lack of mixing, or engine design such as mixing of fan and core air.

(2) *Sample transfer.* The sample system transport time as measured from the sample probe to the entrance to the instrumentation system must be shown by calculation using the physical characteristics of the sample line to be 2 seconds or less. The sample shall be transferred from the probe to the instrumentation system through a heated sample line of either stainless steel or Teflon of 4.5 to 8.2 mm I.D. The sample lines shall be maintained at a temperataure of 150°±5° C.

(3) *Sample line length.* The sample line length from the probe exit to the instrumentation system shall be of minimum length, but in no case greater than 24.5 metres.

(4) *Sampling system for use with reheat (afterburning).* For engines which employ reheat, a sampling system selected by the manufacturer may be used for tests during afterburner (reheat) operation if shown to yield representative results and if approved in advance by the Administrator.

(d) *Component description (exhaust gas analytical system).* The following components shall be used in the exhaust gas analytical system for testing under the regulations in this subpart. The analytical system provides for the determination of hydrocarbon concentrations by flame ionization detector analysis, the determination of carbon monoxide and carbon dioxide concentrations by nondispersive infrared analysis and the determination of oxides of nitrogen concentrations by chemiluminescence analysis of exhaust sample. The chemiluminescence method of analysis requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator. See Appendix A of this part.

§ 87.65 Information to be recorded.

The following information, as applicable, shall be recorded with respect to each test.

(a) *General.* (1) Facility performing tests.

(2) Description of test equipment including the probe and sampling and analytical train.

(3) Instrument operator.

(4) Test stand operator.

(5) Fuel identification, including H/C ratio and additives, if any.

(b) *Aircraft (in which engine will be installed) description.* (1) Manufacturer.

(2) Model number.

(3) Serial number (if known).

(4) User.

(5) Engine installation position.

(c) *Engine description.* (1) Manufacturer.

(2) Model number.

(3) Serial number.

(4) Time since overhaul and other pertinent maintenance information.

(d) *Test data.* (1) Test number.

(2) Date.

(3) Time.

(4) Ambient temperature and engine inlet temperature.

(5) Barometric pressure.

(6) Absolute humidity.

(7) Sample line temperature. Line temperature shall be taken at a minimum of three locations, two of which shall be the probe outlet and instrumentation inlet.

(8) Sample system transport time. (i) Test date. (ii) Supporting calculations.

(9) All pertinent instrumentation information such as tuning, gain, full scale range.

(10) Recorder charts: Identify zero, span, exhaust gas sample traces, and operating mode.

(11) Date of most recent analytical assembly calibration and identification number, if any.

(12) CO, CO_2, HC, and NOx emission measurement system response time for the current and previous test. Record test date and test number of previous test.

(e) *Operating mode data.* (1) Nominal power setting.

(2) Actual power setting (thrust, shaft power, etc.).

(3) N_1 speed, revolutions per minute.

(4) N_2 speed and N_3, if applicable, revolutions per minute.

(5) Measured fuel flow, kilograms/hour.

(6) Air flow, kilograms/second and method of determination.

(7) Service bleed air flow, kilograms/second and pressure.

(8) Shaft power extraction for auxiliary gearbox-mounted components.

(9) PT_7.

(10) EPR.

(11) TT_7.

(12) Pollutant concentration, from recorders, in percent or parts per million by volume, and parts per million carbon for hydrocarbons.

§ 87.66 Calibration and instrument checks.

(a) Calibrate the analytical assembly at least once every 30 days. Use the same flow rate as when analyzing samples.

(1) Adjust analyzers to optimize performance.

(2) Zero the hydrocarbon analyzer with zero grade air and the carbon monoxde, carbon dioxide, and oxides of nitrogen analyzers with zero grade nitrogen. The allowable zero gas impurity concentrations should not exceed 0.1 p.p.m. equivalent carbon response, 1 p.p.m. carbon monoxide, 350 p.p.m. carbon dioxide, and 0.1 p.p.m. nitric oxide.

(3) Set the CO and CO_2 analyzer gains to give the desired range. Select desired attenuation scale of the HC analyzer and adjust the electronic gain control to give the desired full scale range. Select the desired scale of the NOx analyzer and adjust the phototube high voltage supply or amplifier gain to give the desired range.

(4) Calibrate the HC analyzer with propane (air diluent) gases having nominal concentrations equal to 50 and 95 percent of full scale of each range used. Calibrate the CO analyzer with carbon monoxide (nitrogen diluent) gases and the CO_2 analyzer with carbon dioxide (nitrogen diluent) gases having nominal concentrations equal to 30, 60, and 90 percent of full scale of each range used. Calibrate the NO_x analyzer with nitric oxide (nitrogen diluent) gases having nominal concentrations equal to 50 and 95 percent of full scale of each range used. The actual concentrations should be known to within ±2 percent of the true values.

(5) Compare values obtained on the CO and CO_2 analyzers with previous calibration curves. Any significant change reflects some problem in the system. Locate and correct problem, and recalibrate. Use best judgment in selecting curves for data reduction. Log gain reading.

(6) Check the NOx to NO converter efficiency by the following procedure. Use the apparatus described and illustrated in Figure 2.

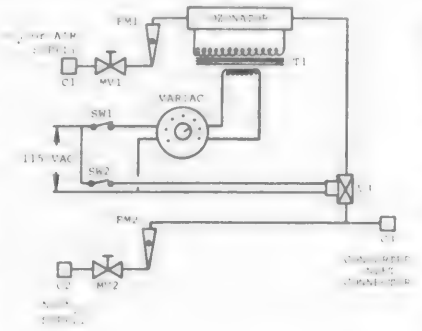
(i) Attach the NO/N_2 supply (150–250 p.p.m.) at C_2, the O_2 supply at C_1 and the analyzer inlet connection to the efficiency detector at C_3. If lower concentrations of NO are used, air may be used in place of O_2 to facilitate better control of the NO_2 generated during step (iv).

(ii) With the efficiency detector Variac off, place the NOx convertor in bypass mode and close valve V3. Open valve MV2 until sufficient flow and stable readings are obtained at the analyzer. Zero and span the analyzer output to indicate the value of the NO concentration being used. Record this concentration.

(iii) Open valve V3 (on/off flow control solenoid valve for O_2) and adjust valve MV1 (O_2 supply metering valve) to blend enough O_2 to lower the NO concentration (ii) about 10 percent. Record this concentration.

(iv) Turn on the ozonator and increase its supply voltage until the NO concentration of (iii) is reduced to about 20 percent of (ii). NO_2 is now being formed from the NO+O_2 reaction. There must always be at least 10 percent unreacted NO at this point. Record this concentration.

Figure 2 - NO_x CONVERTER EFFICIENCY DETECTOR



(v) When a stable reading has been obtained from (iv), place the NOx converter in the convert mode. The analyzer will now indicate the total NOx concentration. Record this concentration.

(vi) Turn off the ozonator and allow the analyzer reading to stabilize. The mixture NO+O_2 is still passing through the converter. This reading is the total NOx concentration of the dilute NO span gas used at step (iii). Record this concentration.

(vii) Close valve V3. The NO concentration should be equal to greater than the reading of (ii) indicating whether the NO contains any NO_2.

Calculate the efficiency of the NOx converter by substituting the concentrations obtained during the test into the following equation.

$$\% \text{ Eff.} = \frac{(v) - (iv)}{(vi) - (iv)} \times 100\%$$

The efficiency of the converter should be greater than 90 percent. Adjusting the converter temperature may be needed to maximize the efficiency. Efficiency checks should be made on each analyzer range using an NO span gas concentration appropriate to the instrument range.

(viii) If the converter efficiency is not greater than 90 percent, the cause of the inefficiency shall be determined and corrected before the instrument is used.

(ix) The converter efficiency shall be checked at least once weekly and preferably once daily.

(b) Verifications and instrument checks shall be performed in accordance with § 87.67 on in-use systems. Verification and instrument checks shall be performed before and after each test, but not less than once per hour.

(c) For the purposes of this section, the term "zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18- and 21-mole percent.

§ 87.67 Sampling procedures.

(a) *HC, CO, CO_2, and NOx measurements.* Allow a minimum of 2 hours warmup for the CO, CO_2, HC, and NOx analyzers. (Power is normally left on infrared and chemiluminescence analyzers; but when not in use, the chopper motors of the infrared analyzers are turned off and the phototube high voltage supply of the chemiluminescence analyzer is placed in the standby position). The following sequence of operations shall be performed in conjunction with each series of measurements:

(1) Check the sampling system for any leaks that could dilute the exhaust gas and replace or clean sample line filters.

(2) Introduce the zero grade gas at the same flow rates used to analyze the test samples and zero the analyzers. Obtain a stable zero on each amplifier meter and recorder. Recheck after tests.

(3) Introduce span gases and set the CO and CO_2 analyzer gains, the HC analyzer sample capillary flow rate and electronic gain control, if provided, and the NOx analyzer high voltagae supply or amplifier gain to match the calibration curves. In order to avoid corrections, span and calibrate at the same flow rates used to analyze the test samples. Span gases should have concentrations equal to approximately 80 percent of each range used. If gain has shifted significantly on the CO or CO_2 analyzers, check tuning. If necessary, check calibration. Respan at least at end of test but not less than once per hour. Show actual concentrations on chart. Log gain readings.

(4) Check zeros; repeat the procedure in subparagraphs (1) and (2) of this paragraph, if required.

(5) Check the sample system line temperature. Also check the emission measurement system response time using the following procedure:

(i) In addition to the requirements of § 87.64, the sample system transport time shall be rechecked each time the emission measurement system is modified in any manner which may reasonably be expected to change the sample system transport time.

(ii) The emission measurement system response time shall be checked. Introduce an HC span gas at the sample probe and measure the time it takes for the instrument to respond to

15 percent of span concentration. The emission measurement system response time shall be 7 seconds or less.

(iii) Repeat (ii) for the CO, CO_2, and NOx instrumentation. The emission measurement system response time for all instruments shall be 7 seconds or less except for the NOx chemiluminescence instrument which shall have a response time of 9 seconds or less.

(iv) The results of (ii) and (iii) must compare with the emission measurement system response times of the previous test within ±1.0 second.

(6) Check instrument flow rates and pressures.

(7) The engine shall be operated in each operating mode until emission levels have stabilized as indicated by a constant instrument reading or recorder output. This stabilized reading shall be recorded and used in calculating mass emission rates as called for in Section 87.70.

(8) Measure, HC, CO, CO_2, and NOx concentrations of the exhaust sample at the various modes called for in § 87.62.

(9) If individual probes are used, the number to be reported (for each component) shall be the arithmetic average of the values obtained at each sampling point. If mixing probes are used, the number to be reported shall be the average of the values of the several probes, giving each probe a weighting factor equal to the number of sample points in that particular probe.

(10) Recheck zero and span points at the end of the test and also at approximately one hour intervals during the test. If either has changed by ±2 percent of full scale, the test shall be rerun after instrument maintenance: *Provided*, That if it is impractical to repeat the test, a correction based on an interpolation which is linear with time is acceptable for corrections within ±4 percent.

(b) *Sample system contamination.* (1) Care shall be taken to avoid loading of the sampling system with raw fuel discharge during engine starting.

(2) When the sample probe is in the exhaust stream and sampling is not in process, a back purge with air or an inert gas may be necessary to protect the probe and sample line from particulate buildup which could affect smoke and hydrocarbon readings. Check sample line for contamination each time the instrument zero and span points are checked. Use the following procedure to check the sample line:

(i) Immediately after instrument zero and span measurements and necessary adjustments are complete, introduce hydrocarbon zero gas near the sample probe. If the instrument zero reading increases by more than 5 percent of the scale in use, the sample line shall be purged or cleaned as required, to bring the zero within limits.

(ii) When the requirements of (i) have been met, introduce hydrocarbon span gas into the inlet of the sampling system. If the instrument span reading is different by more than ±5 percent from the correct setting for the scale in use, the sample line shall be purged or cleaned, as required, to bring the span within limits.

§ 87.68 Test run.

A test run shall consist of operating the engine in accordance with § 87.62. During the test run the engine shall not be operated at a power setting above normal idle power before beginning the test sequence of § 87.62. The engine shall be operated in the sequence called for under this section, unless an alternate procedure is agreed to in writing by the Administrator before such testing is conducted. If repeat runs at full takeoff power are necessary, they may be conducted after the last idle run in the test sequence.

§ 87.69 Chart reading.

Determine the HC, CO, CO_2, and NOx concentrations of the exhaust sample during the various modes from the instrument deflections or recordings, making use of appropriate calibration charts.

§ 87.70 Calculations.

(a) The final reported test results shall be computed by use of the following formulas:

(1) Hydrocarbon:

HC grams/kilonewtons-thrust or kilowatts, as appropriate/cycle=

Sum of the HC mass/mode of each mode

Rated power

(2) Carbon monoxide:

CO grams/kilonewtons-thrust or kilowatts, as appropriate/cycle=

Sum of the CO mass/mode of each mode

Rated power

(3) Oxides of nitrogen:

NOx grams/kilonewtons-thrust or kilowatts, as appropriate/cycle=

Sum of the NOx mass/mode of each mode

Rated power

(b) The pollutant mass per mode shall be computed by use of the following formulas:

(1) HC mass/mode=HC emission rate×TIM.

(2) CO mass/mode=CO emission rate×TIM.

(3) NOx mass/mode=NOx emission rate×TIM.

(c) The emission rates of each mode shall be computed by use of the following formulas:

(1) HC emission rate $= \dfrac{M_{HC}\frac{(HC)}{10^4}F}{(M_C+aM_H)\left(\frac{(CO)}{10^6}+(CO_2)+\frac{(HC)}{10^4}\right)}$

(2) CO emission rate $= \dfrac{M_{CO}\frac{(CO)}{10^4}F}{(M_C+aM_H)\left(\frac{(CO)}{10^6}+(CO_2)+\frac{(HC)}{10^4}\right)}$

(3) NOx emission rate $= \dfrac{M_{NO_2}\frac{(NOx)}{10^4}F}{(M_C+aM_H)\left(\frac{(CO)}{10^6}+(CO_2)+\frac{(HC)}{10^4}\right)}$

(d) The times in mode (TIM) shall be as specified below:

Times in mode (minutes)	Class P2	Class T1, T2, Class T3 or T4	Class T5
(1) Taxi/idle (out)	19.0	19.0	19.0
(2) Takeoff	.5	.7	1.2
(3) Climbout	2.5	2.2	2.0
(4) Descent	NA	NA	1.2
(5) Approach	4.5	4.0	2.3
(6) Taxi/idle (in)	7.0	7.0	7.0

(e) Meaning of symbols:

(1)(i) HC mass/mode=Total mass of hydrocarbon emissions in grams emmitted during an operation mode as specified in § 87.62 and paragraph (d) of this section.

(ii) CO mass/mode=Total mass carbon monoxide emissions in grams emitted during an operational mode as specified in § 87.62 and paragraph (d) of this section.

(iii) NOx mass/mode=Total mass of oxides of nitrogen emissions in grams enitted during an operational mode as specified in § 87.62 and paragraph (d) of this section.

(2)(i) HC emission rate=grams/hour of exhaust hydrocarbons emitted in an operational mode.

(ii) CO emission rate=grams/hour of exhaust carbon monoxide emitted in an operational mode.

(iii) NOx emission rate=grams/hour of exhaust oxides of nitrogen emitted in an operational mode.

(3)(i) M_{HC}=Molecular weight of methane, M_{HC}=16.04.

(ii) M_{CO}=Molecular weight of carbon monoxide.

(iii) M_{NO_2}=Molecular weight of nitrogen dioxide.

(iv) M_C=Atomic weight of carbon.

(v) M_H=Atomic weight of hydrogen, M_H=1.008.

(vi) a=Atomic hydrogen-carbon ratio of fuel.

(4) For each operating mode:

(i) (HC)=Concentration of hydrocarbons in the exhaust sample in parts per million carbon equivalent, i.e., equivalent propane ×3.

(ii) (CO)=Concentration of carbon monoxide in the exhaust sample in parts per million by volume.

(iii) (CO_2)=Concentration of carbon dioxide in the exhaust sample in volume percent.

(iv) (NOx)=Concentration of oxides of nitrogen in the exhaust sample in parts per million by volume, $NO+NO_2$.

(v) F=Mass rate of fuel flow in kilograms per hour.

(5) TIM=Time in mode as specified in paragraph (d) of this section, divided by 60 to yield time in mode in hours.

§ 87.71 Compliance with emission standards.

Compliance with each emission standard by any aircraft engine shall be determined by comparing the pollutant level in grams/kilonewton thrust/cycle or grams/kilowatt/cycle as calculated in § 87.70(a) with the applicable emission standard under this part. The pollutant level for the cycle shall not exceed the standard.

Subpart H—Test Procedures for Engine Smoke Emission (Aircraft Gas Turbine Engines)

§ 87.80 Introduction.

Except as provided under § 87.5, the procedures described in this subpart shall be the test program to determine the conformity of new and in-use gas turbine engines with the applicable standards set forth in this part. The test is essentially the same as that described in §§ 87.60–87.62, except that the test is designed to determine the smoke emission level at various operating points representative of engine usage in aircraft. Other smoke measurement systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

§ 87.81 Fuel specifications.

Fuel having specifications as provided in § 87.61 shall be used in smoke emission testing.

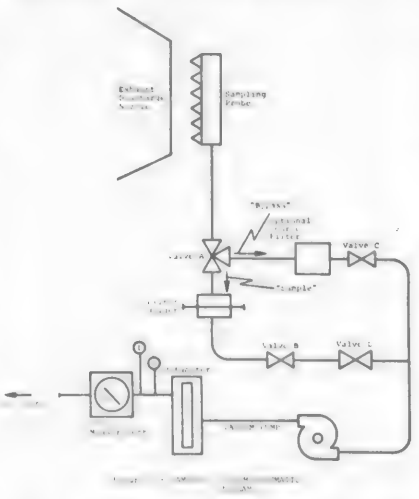
§ 87.82 Sampling and analytical system for measuring smoke exhaust emissions.

(a) *Schematic drawing.* Figure 3 is a schematic drawing of the exhaust smoke sampling and analytical system which shall be used in testing under the regulation in this subpart.

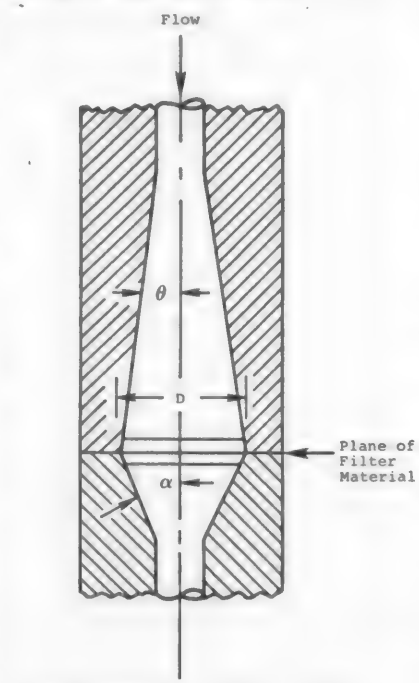
(b) *Component description.* The following components shall be used in the sampling and analytical system for testing under the regulations in this subpart.

(1) *Sample size measurement.* A wet or dry positive displacement meter shall be used to measure sample size to an accuracy of ±0.283 standard litre. Pressure and temperature shall be measured immediately upstream of meter. Accuracy shall be no less than ±2.5 mm. Hg and ±2° C, respectively. If a dry type meter in used, it may be located between the filter holder and the vacuum pump.

(2) *Sample flow rate measurement.* Sample flow rate shall be measured with a rotameter with accuracy of no less than ±0.01 litre per second.



(3) *Filter holder.* The filter holder shall firmly clamp the filter material so that overall system leakage does not exceed that provided in § 87.84(c). The holder internal geometry shall be such that the variation of SN over the sample spot surface is not greater than two. Required elements of the filter holder design are given in Figure 4. The filter holder shall be made of corrosion resistant material.



D (Spot diameter) = 0.50 to 1.50 in.
θ = 5° to 7.5°
α = 20° to 30°

Figure 4 - FILTER HOLDER SCHEMATIC DIAGRAM

(4) *Sampling probe.* The sample probe and procedure shall be the same as used to show compliance with § 87.64(c).

(5) *Sampling lines.* The sampling lines shall be straight through with no kinks or loops, and no bends having a radius of less than 10 line diameters. Sampling line inside diameter shall be within 4.5 to 8.2 mm. The sampling line section from the probe exit to valve A entrance shall be of minimun length, not greater than 23 metres with a minimum of fittings or other breaks. Line material shall be such as to not encourage build-up of either particulate matter or static electric charge, such as stainless steel or copper.

(6) *Valving.* Four valve elements shall be provided. Valve A shall be a quick acting, full-flow, flow diverter with "closed", "sample", and "bypass" positions. Valve A may consist of two valves: *Provided,* That they are interlocked so that one of the pair cannot act independently of the other. Valves B and C shall be throttling valves used to establish a system flow rate. Valve D shall be a shutoff valve used in isolating the filter holder. All valves shall be made of corrosion resistant material.

(7) *Vacuum pump.* The vacuum pump shall have a no-flow vacuum capability of at least 560 mm hg V, and full-flow capacity of 0.48 standard litre per second minimum.

(8) *Reflectometer.* A reflectometer conforming to ASA standard for diffues reflection density, number Ph 2.17-1958, shall be used. The diameter of the reflectometer light beam on the filter paper shall be no more than one-half of "D", the diameter of the filter spot. The allowable range of "D" is given in Figure 4.

(9) *Filter material.* The filter material shall be Whatman No. 4 filter paper or equivalent approved by the Administrator.

§ 87.83 Information to be recorded.

The following information shall be recorded with respect to each test in addition to that information called for in § 87.65 (a) through (c).

(a) Sample temperature.

(b) Sample pressure.

(c) Actual sample volume at sampling conditions.

(d) Actual sample flow rate at sampling conditions.

(e) Leak and cleanliness checks substantiation as required by § 87.84 (b) and (c).

§ 87.84 Calibration and instrument checks.

(a) *Reflectometer calibration.* The reflectometer required by § 87.82(b)(8) shall be calibrated in accordance with manufacturer's specifications.

(b) *System maintenance.* The need for cleaning or replacement shall be determined by conducting the following cleanliness check:

(1) Full open valves B, C, and D.

(2) Use the vacuum pump and alternately set valve A to "bypass" and "sample" to purge the entire system with clean air for at least 5 minutes.

(3) Set value A to "bypass".

(4) Close valve D and clamp clean filter material into the holder. Open valve D.

(5) Set valve A to "sample", reset back to "bypass" after 0.0439 standard litre of air per square millimetre of filter area has passed through the filter material.

If the filter spot exhibits SN greater than 3, the system lines must be cleaned or replaced. The system shall not be used until this cleanliness requirement has been met.

(c) *Leak check.* The following procedure shall be used to leak check the system.

(1) Clamp clean filter material into the holder.

(2) Close valve A, full open valves B, C, and D.

(3) Run the vacuum pump for 5 minutes.

The system shall be satisfactory if no more than 5.6 standard litres passed through the volume meter during 5 minutes. The system shall not be used until this requirement has been met.

§ 87.85 Test procedures.

(a) The engine shall be operated as provided in § 87.62. The leak check and cleanliness check requirements of § 87.84 shall be confirmed before and after each engine test. The test shall be repeated if the requirements of § 87.84 are not confirmed.

(b) Precautions: The material being measured is composed of low-micron and/or submicron size agglomerated particles. Precautions should be taken to assure that steady state conditions have been achieved prior to taking a sample. To prevent material accumulation, the system shall not be left in a no-flow condition when exhaust gas is contained.

(c) Sampling: Not less than 1 minute shall be allowed to assure that the system is fully charged with a representative gas sample. The sampling flow rate shall be maintained at 0.236±0.009 litres per second. At least four sample sizes shall be taken within the range of 0.0054 to 0.080 grams of exhaust gas per square millimetre of filter. Samples shall be taken both above and below 0.0162 gm. of exhaust gas per square millimetre of filter.

(d) Temperature control: The gas temperature from the sampling probe entrance to the filter material shall be above the dew point temperature. All lines and valves shall be lagged and/or heated as necessary to meet this requirement.

(e) Preparation for each power setting: The following shall be done to prepare the system at each power setting:

(1) Set valve A to "bypass", close valve D.

(2) Draw exhaust gas for 5 minutes minimum, then use valve C to set flow rate at 0.236±0.009 litre per second.

(3) Clamp clean filter material into the holder.

(4) Open valve D.

(5) Set valve A to "sample" and use valve B to again set the flow rate to 0.236±0.009 litre per second. This shall be done quickly before particulate buildup on the filter causes excessive pressure drop.

(6) Set valve A to "bypass" and close valve D.

(7) Clamp clean filter material into the holder.

(f) Sampling procedure: The procedure for smoke sampling at each power setting shall be as follows:

(1) With valve D closed and valve A set at the "bypass" position, charge the lines with exhaust gas for 1 minute minimum. Reestablish flow rate at 0.236±0.009 litre per second as required, using valve C.

(2) Open valve D.

(3) Set valve A to "sample", allow the chosen sample volume to pass, then set valve A to "bypass".

(4) Close valve D and clamp clean filter material into the holder.

(5) Repeat subparagraphs (2) through (4) of this paragraph for at least three more sample sizes in accordance with paragraph (c) of this section.

§ 87.86 Test run.

With respect to engine operation, the test run shall be conducted in accordance with § 87.68.

§ 87.87 Determination of SN.

Smoke spot analysis shall be made with a reflectometer as specified in § 87.82(b)(8). The backing material shall be black with a maximum absolute reflectance of 3 percent. The reflectance reading of each spot shall be used to calculate SN by:

$SN=100[1-(Rs/Rw)]$,

where

Rs=absolute reflectance of the sample spot.

Rw=absolute reflectance of clean filter material.

§ 87.88 Calculations.

(a) *Calculation of W.* The sample mass (w) shall be calculated by:

$W\,(gm)=0.465(PV/T)$,

where P and T are sample pressure and temperature in units of millimetres of mercury absolute and degrees Kelvin, respectively, measured immediately upstream of the volume meter. V is the measured sample volume in litres.

(b) *Calculation of W/A.* The sample mass in grams per square millimetres of filter spot area (W/A) shall be calculated for each sample size taken.

(c) *Plotting SN versus W/A.* All SN shall be plotted as a function of W/A on semilog coordinates with W/A as the logarithmic abscissa. A straight line shall be fitted to these points using the method of least squares. Such a line shall be produced for each power setting specified.

(d) *Plotting reporting values of SN versus power setting.* Values of SN shall be read from the straight line functions of paragraph (c) of this section for W/A=0.0162 gm/sq.mm. These SN are the values to be reported and shall be presented by plotting them as a function of power setting on rectangular coordinates.

§ 87.89 Compliance with emission standards.

Compliance with each emission standard shall be determined by comparing the plot of SN as a function of power setting from § 87.88 with the applicable emission standard under this part. The SN at every power setting shall not exceed the standard.

Subpart I—[Reserved]

Subpart J—Temporary Exemption From Aircraft Emission Standards (Fuel Venting and Smoke)

§ 87.101 Application for temporary exemption.

(a) The Administrator of the Environmental Protection Agency may grant to any aircraft or aircraft engine temporary exemption from any applicable standard under § 87.11(a) or § 87.31(a), provided that the owner or operator of such aircraft or aircraft engine demonstrates:

(1) All good faith efforts to achieve compliance with such standard,

(2) Inability to comply with such standard due to circumstances beyond his control, and

(3) A plan by which he will achieve such compliance in the shortest time which is feasible.

(b) Applications for temporary exemption from the requirements of § 87.31(a) shall be submitted in duplicate to the Administrator of the Environmental Protection Agency and shall contain the following information:

(1) The name and address of the applicant,

(2) The standard or requirement from which temporary exemption is requested,

(3) The number of aircraft or aircraft engines subject to the requirement for which a temporary exemption is requested,

(4) The efforts made by the applicant to accomplish compliance, including ordering of equipment and scheduling of maintenance work, and the dates of these efforts,

(5) A detailed statement of reasons why the applicant will not be in compliance when the standard or requirement becomes effective,

(6) The name of the equipment supplier and/or the name of the firm retained to perform the maintenance work,

(7) The applicant's proposed timetable for installation of equipment and obtaining necessary approvals for each aircraft or aircraft engine for which temporary exemption is requested, and

(8) The name of the person responsible for accomplishing compliance according to the timetable proposed by the applicant.

(c) Prior to taking action on an application for temporary exemption, the Administrator shall consult with the Secretary of Transportation. A copy of the applicant's request should be submitted by the applicant to the Secretary of Transportation.

(d) The Administrator shall publish in the FEDERAL REGISTER the name of the the owner or operator to whom a temporary exemption is granted and the period of such exemption.

(e) No state or political subdivision thereof may attempt to enforce a standard respecting fuel venting or smoke emissions from an aircraft or engine if such aircraft or engine has been granted an exemption from such standard.

§ 87.102 Thirty-day suspension of fuel venting and smoke standards.

(a) The applicability of the standards of § 87.11(a) and § 87.31(a) to aircraft subject to such standards is suspended until February 1, 1974.

(b) Application for temporary exemption from the standards of § 87.11(a) and § 87.31(a) for aircraft which will not be in compliance by February 1, 1974, must be submitted in accordance with the procedures of § 87.101.

APPENDIX A—INSTRUMENTATION (AIRCRAFT GAS TURBINE ENGINE MEASUREMENTS)

(a) *NDIR instruments.* Nondispersive infrared (NIDR) analyzers, shall be used for the continuous monitoring of carbon monoxide and carbon dioxide.

The NDIR instruments operate on the principle of differential energy absorption from parallel beams of infrared energy. The energy is transmitted to a differential detector through parallel cells, one containing a reference gas, and the other, sample gas. The detector, charged with the component to be measured, transduces the optical signal to an electrical signal. The electrical signal thus generated is amplified and continuously recorded. The NDIR analyzer used in accordance with Subpart H of this part shall meet the following specifications:

(1) *Response time (electrical).* 90 percent full scale response in 0.5 seconds or less. Zero drift—less than ±1 percent of full scale in 2 hours on most sensitive range. Span drift—less than ±1 percent of full scale in 2 hours on most sensitive range. Repeatability—±1 percent of full scale. Noise—less than 1 percent of full scale on most sensitive range. Cell temperature—minimum 50° C maintained within 2° C.

(2) *Range and accuracy.*

Range	Accuracy excluding interferences
Carbon monoxide:	
0 to 100 ppm	± 2 pct of full scale.
0 to 500 ppm	± 1 pct of full scale.
0 to 2,500 ppm	Do.
Carbon dioxide:	
0 to 2 pct	Do.
0 to 5 pct	Do.

(3) All NDIR instruments shall be equipped with cells of suitable length to measure exhaust concentrations within the ranges encountered to the indicated accuracy. Range changes shall be accomplished either by the use of stacked sample cells or changes in the electronic circuitry, or both.

(b) *Total hydrocarbon analyzer.*—(1) *General design specifications.* The measurement of total hydrocarbon is made by an analyzer using a flame ionization detector (FID). With this type dtector an ionization current, proportional to the mass rate of hydrocarbon entering a hydrogen flame, is established between two electrodes; the small current is measured by an electrometer amplifier and continuously recorded.

The analyzer shall be fitted with a constant-temperature oven housing the detector and sample-handling components. It shall maintain temperature within ±2° C of the set point, which shall be within 155° to 165° C.

The detector and sample handling components shall be suitable for continous operation at temperatures to 200° C.

(2) The FID analyzer used in accordance with Subpart G of this part shall meet the following specifications:

Response time (electrical)—90 percent of full scale in 0.5 seconds or less.

Noise—±1 percent of full scale on most sensitive range.

Repeatability—±1 percent of full scale.

Zero drift—less than ±1 percent of full scale in 2 hours on all ranges.

Span drift—less then ±1 percent of full scale in 2 hours.

Linearity—Response with propane in air shall be linear with ±2 percent over the range of 0 to 2000 ppmC.

Accuracy: 0 to 10 ppmC—±5 percent of full scale with propane calibration gas.

0 to 100 ppmC—±2 percent of full scale with propane calibration gas.

0 to 1,000 ppmC—± 1 percent of full scale with propane calibration gas.

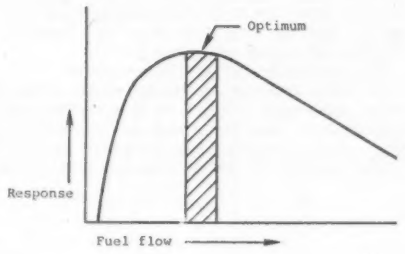
0 to 2,000 ppmC—±1 percent of full scale with propane calibration gas.

(3) Total hydrocarbon analyzer shall have an initial alignment as follows:

(i) *Optimization of detector response.* (*a*) Follow manufacturer's instructions for instrument start-up and basic operating adjustment. Fuel shall be 60 percent helium, 40 percent hydrogen containing less than 2 ppmC hydrocarbon. Air shall be "hydrocarbon-free" grade containing less than 2 ppmC.

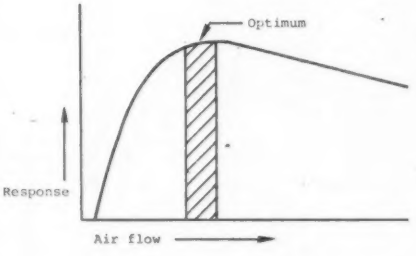
(*b*) Set oven temperature at 160° ±5° C and allow at least one-half hour after oven reaches temperature for the system to equilibrate. The temperature is to be maintained at set point ±2° C.

(*c*) Introduce a mixture of propane in air at a propane concentration of about 500 ppmC. Vary the fuel flow to burner and determine the peak response. A change in zero may result from a change in fuel flow; therefore, the instrument zero should be checked at each fuel-flow rate. Select an operating flow rate that will give near maximum response and least variation in response with minor fuel-flow variations. A typical curve for response versus fuel flow is shown in the following figure.



RESPONSE VS. FUEL FLOW

(*d*) To determine the optimum air flow, use fuel flow setting determined above and vary air flow. A typical curve for response versus air flow is shown in the following figure:



RESPONSE VS. AIR FLOW

After the optimum flow settings have been determined these flows are to be measured and recorded for future reference.

(ii) *Oxygen effect.* Check the response of the detector with varied concentrations of oxygen in the sample following the steps outlined below; this test shall be made with oven temperature at the set point and with gas flow to the detector at optimum conditions, as determined in paragraph (b)(3)(i) of this section.

(*a*) Introduce nitrogen (N_2) zero gas and zero analyzer; check zero using hydrocarbon-free air; the zero should be the same.

(*b*) The following blends of propane shall be used to determine the effect of oxygen (O_2) in the sample.

Propane in N_2.

Propane in 10%±0.5% O_2 and balance N_2.
Propane in zero grade air (refer to § 87.66(c)).

The volume concentration of propane in the mixtue reaching the detector should be about 500 ppmC, and the concentration of both the O_2 and hydrocarbon should be known within ±1 percent of the absolute value. The zero shall be checked after each mixture is measured. If the zero has changed then the test shall be repeated.

The response to propane in air shall not differ by more than 3 percent from the response to propane in the 10 percent-O_2/90 percent-N_2 mixture, nor differ by more than 5 percent from the response to propane in nitrogen.

The difference between the response to propane in nitrogen and response to propane in dilutent containing 10 percent O_2 shall not exceed 2 percent. If the 2 percent specification cannot be met by changing the sample flow rate or burner parameters, such as air and/or fuel-flow rate, the detector shall be modified or replaced.

(iii) Linearity and relative response.

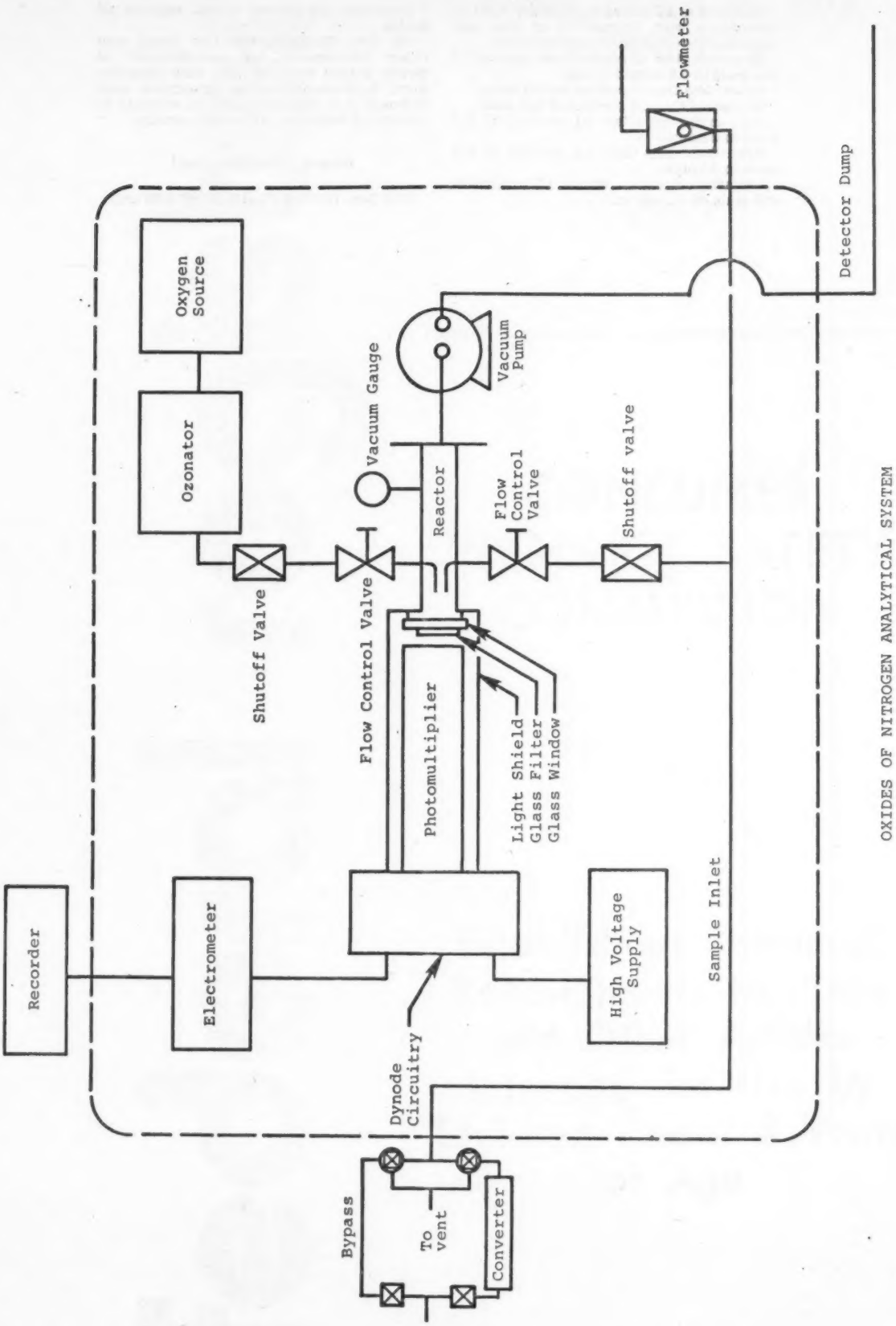
(*a*) With analyzer optimized in accordance with paragraph (b)(3)(i) of this section, the instrument linearity shall be checked for the ranges covering the range of analysis using propane in air at nominal concentrations of 30, 60, and 90 percent full scale of each range. The deviation of a best-fit curve from a least-squares best-fit straight line should not exceed 2 percent of the value at any point. If this specification is met, concentration values may be calculated by use of a single calibration factor. If the deviation exceeds 2 percent at any point, concentration values shall be read from a calibration curve prepared during this alignment procedure.

(*b*) A comparison of response to the different classes of componds shall be made using (individually) propylene, toluene, n-hexane, and propane, each at 20 to 50 ppmC concentration in air. If the response to propylene, toluene or n-hexane differs by more than 5 percent from the response to propane, check instrument operating parameters. Reducing sample flow rate improves uniformity of response.

(*c*) *Oxides of nitrogen analytical system.* The chemiluminescence method utilizes the principle that nitric oxide (NO) reacts with ozone (O_3) to give nitrogen dioxide (NO_2) and oxygen (O_2). Approximately 10 percent of the NO_2 is electronically excited. The transition of excited NO_2 to the ground state yields a light emission (600–2600 nanometer region) at low pressures. The detectable region of this emission depends on the PM-tube/optical filter being used in the detector. The intensity of this emission is proportional to the mass flow rate of NO into the reactor. The light emission can be measured utilizing a photomultiplier tube and associated electronics.

The method also utilizes the principle that the thermal decomposition of NO_2 (i.e., $2NO_2 \rightarrow 2NO + O_2$), is complete at about 600° C. The rate constant for the dissociation of NO_2 at 600° C is approximately 10^4 (litres/mole-second). A 1.83 metre length of 3.175 mm outside diameter, 0.711 mm wall thickness, flawless stainless steel tubing resistance heated using a low voltage, high current power supply to a temperature of 650° C provides sufficient residence time at a sample flow rate of 700 cc per minute for essentially complete conversion of nitrogen dioxide to nitric oxide. Other converter designs may be used if shown to yield equivalent results.

The method permits continuous monitoring of NOx concentrations over a wide range. Response time (2 to 4 seconds is typical) is primarily dependent on the mechanical pumping rate at the operating pressure of the reactor. The following figure is a flow schematic illustrating one configuration of the major components required for the oxides of nitrogen analytical system.



OXIDES OF NITROGEN ANALYTICAL SYSTEM

The oxides of nitrogen analyzer used in accordance with Subpart G of this part shall meet the following specifications:

Response time (electrical)—90 percent of full scale in 0.5 second or less.

Noise—less than 1 percent of full scale.

Repeatability—±1 percent of full scale.

Zero drift—less than ±1 percent of full scale in 2 hours.

Span drift—less than ±1 percent of full scale in 2 hours.

Linearity—linear to within ±2 percent of full scale on all ranges.

Accuracy—±1 percent of full scale on all scales.

(*d*) The dynamometer test stand and other instruments for measurement of power output and the fuel flow measurement instrumentation in accordance with Subpart G of this part shall be accurate to within ±2 percent at all power settings.

APPENDIX B—[RESERVED]

[FR Doc. 78-7690 Filed 3-23-78; 8:45 am]